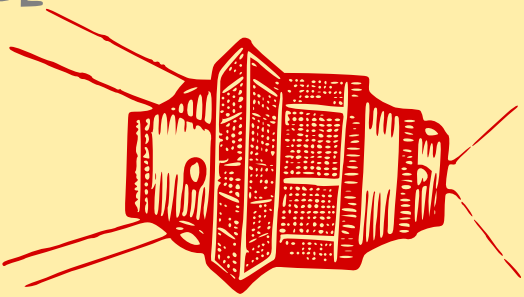
ON THE TRACK OF DISCOVERY

SERIES 2

RIDDLES OF OUTER SPACE

SCIENTISTS UNRAVEL MYSTERIES

SECRETS OF HISTORY



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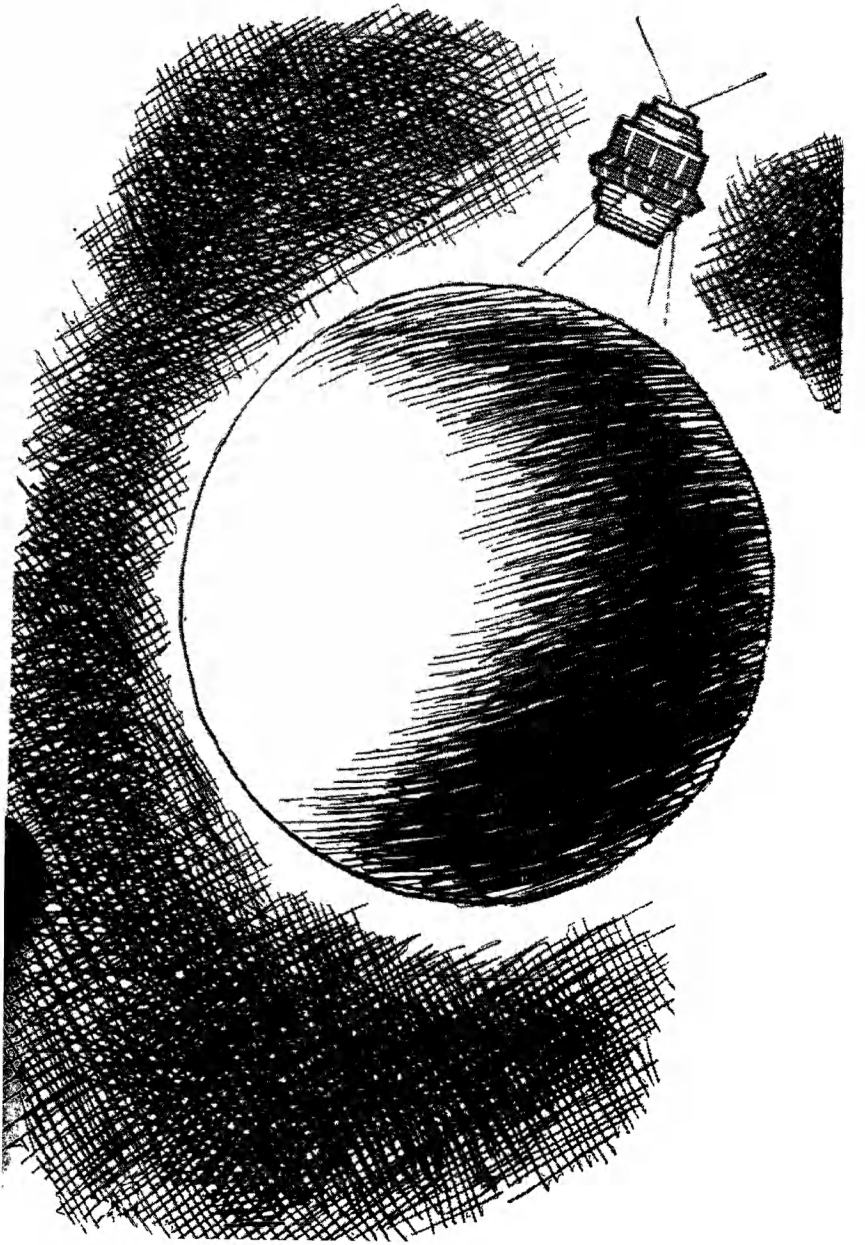


ON THE TRACK OF DISCOVERY

RIDDLES OF OUTER SPACE

SCIENTISTS UNRAVEL MYSTERIES

SECRETS OF HISTORY

SERIES 2

ТАЙНА БЛИЗКА К РАЗГАДКЕ

Загадки космоса
Учёные разгадывают тайны
В мире неразгаданных тайн

На английском языке

TRANSLATED FROM THE RUSSIAN
BY DAVID SKVIRSKY

DESIGNED BY V LEVINSON

CONTENTS

Page

I. RIDDLES OF OUTER SPACE

TEN RIDDLES OF THE MOON *by L. Yuryev* . . 9

COMMUNITY OF WORLDS *by Vladimir Lvov* . . 27

II. SCIENTISTS UNRAVEL MYSTERIES

THE SECRET OF SAAREMAA ISLAND *by L. Kuznetsov and I. Yevgenyev* 41

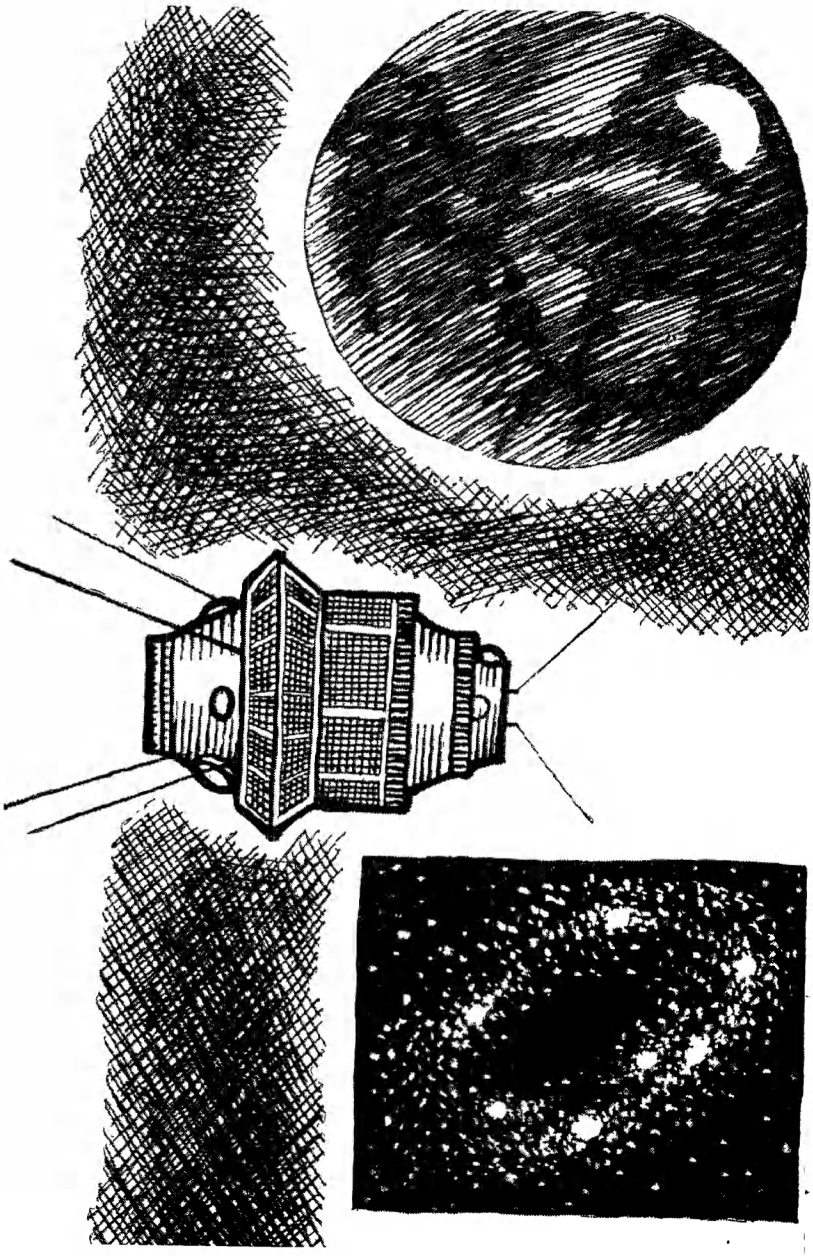
TOWN WITH A DOUBLE BOTTOM *by Lev Uspensky and Ksenıya Schneıder* 101

III. SECRETS OF HISTORY

ARE THERE ANY UNKNOWN ANIMALS IN THE WORLD? *by S. K Klumov* 127

AMID ETERNAL DARKNESS *by Alexander Ryumin* 139

ATLANTIS *by Rudolph Bershadsky* 151



RIDDLES OF OUTER SPACE

TEN RIDDLES OF THE MOON

COMMUNITY OF WORLDS

L. Yuryev

TEN RIDDLES OF THE MOON

The storm had been raging for many days. Furious bursts of wind were whipping the waters into towering waves, letting their crests crash against each other, and ripping the foam and hurling the pieces over enormous distances as though they were the shredded wings of birds. They could no longer distinguish between sea and air. People had lost all sense of time and were submissively waiting for that fatal blow that would crush the ship. They had stopped praying for salvation. But the heart-chilling howling of the wind was gradually beginning to abate. It grew lighter, and the stunned crew saw before them a huge silvery island swimming in the blue sky.

Strange beings inhabited this ideally round island. Some, mounted on giant, three-headed birds, were soaring in the air. Others rode mammoth fleas, which leaped as high as the clouds. Still others....

We cannot bring ourselves to reproach the Greek writer Lucian, who lived more than 2,000 years ago, of exaggerating and distorting truth. After all, the amazing journey to the

Moon so eloquently described by him was, perhaps, the first attempt to penetrate the mysteries of our nearest neighbour in the Universe.

OLD FRIEND

The bewitching, fabulously lovely nocturnal luminary appears in our firmament as soon as twilight wraps itself round the Earth. As it sails majestically in the depths of the heavens, its soft, enchanting light floods the hushed Universe, which seems to have come to a standstill in silent delight.

Small wonder that no other heavenly body, not even the Sun, is associated with so many fearful legends, hair-raising myths, poetical fables and naive superstitions as the Moon.

Yet today, because it is our nearest neighbour in the Universe, we know more about it than about any other heavenly body.

The Moon takes 27 days 7 hours 43 minutes and 11 51 seconds to cover its circular route amid the stars. This interval of time, called the stellar (sidereal) month, is extremely important to astronomers. But that is not the only "month" used in science. Astronomers also distinguish synodical, tropical, anomalistic and dracontic months, which differ considerably from each other.

The reason there are so many months is that the Moon executes extraordinarily intricate movements under the influence of the attraction of the Sun, the Earth and other planets. According to the latest theory, suggested by the American astronomer E. W. Brown, the Moon's position among the stars is described by three equations, the first having 150 members, the second more than 300 and the third 655! That is a complicated motion indeed!

Happily we seldom have to delve into such subtleties

of the behaviour of our cosmic neighbour. In the first approximation we frequently can consider that the Moon moves in an elipsis around the Earth. At the perigee, the point at which it comes closest to our planet, it is 354,000 kilometres away. At the apogee, the point farthest away from the Earth, the distance increases to 405,500 kilometres.

Cosmically speaking, both these distances are infinitesimally short. Indeed, a ray of light makes the journey from the Earth to the Moon in less than a second and a half

Thanks to this proximity scientists have determined the Moon's basic dimensions very accurately. It has a radius of 1,738 kilometres, which is about 27 per cent of the Earth's radius. Its surface area does not exceed 7 5 per cent of the Earth's surface, while its volume hardly reaches 2 per cent of the Earth's.

By observing the movement of the Sun and the planets, scientists have found that the Earth is 81.56 times heavier than the Moon. Once this was established and knowing the Earth's mass, it was not difficult to compute our satellite's mass, which proved to be 7.33×10^{25} grams.

But today these figures do not interest cosmonauts and the builders of spaceships so much as the force of gravity on the Moon, because in many ways it determines how difficult it will be to return to the Earth from one cosmic body or another. The stronger the gravity pull the greater must be the acceleration a spaceship has to develop to break away into the expanses of outer space. To take off from the Earth it requires a speed of 11.2 kilometres per second, while a launching from the immense planet Jupiter requires a velocity of 61 kilometres per second. In order to take off from the Moon it is believed that a velocity of 2 4 kilometres per second is sufficient because the gravity pull there is a sixth of that of the Earth. One can appreciate how much pleasanter this is for the crew of a spaceship.

Besides, on the Moon space travellers will feel remarkably strong. Without much effort they will be able to jump tens of metres into the air or juggle with rocks weighing (according to our terrestrial standards) at least 100 kilos. Seriously speaking, any work on the Moon will be considerably lighter and require much less effort than on the Earth.

A PHOTOGRAPH AND ...

As long as man can remember himself he has been noting the extraordinary feature of the Moon that as it wandered amid the stars it went through various phases, from a thin crescent to a full disk and then back again, growing dark when it entered the shadow of the Earth during eclipses. But the pattern of the dark spots on its luminous face never changed.

Giovanni Riccioli, the seventeenth-century Italian astronomer, introduced a nomenclature for lunar features, calling the largest spots "oceans", the smaller ones "seas", their branches "bays" and the tiny isolated spots "lakes". The name "continent" was given to the light background around the seas, and the regions with an intermediate tone were called "marshes".

This nomenclature is still used although there is now no longer any doubt at all that all these oceans, seas, bays and lakes are completely waterless. Besides, no reeds ever rustled and no water ever shone in the lunar marshes. The nomenclature, therefore, is purely conventional and only reflects the difference in the colouring of the various zones of the totally arid lunar surface.

A photograph of the Moon shows us a fantastic pattern of mountains. Vast plains are bounded by huge rocky ranges, whose peaks reach a dizzy height. There are sheer, sharp-peaked mountains in the plains as well. Here and there several of these mountains stand close together to

form short ranges. Closer to the edge of the plains the peaks are higher, and farther away they assemble into gigantic mountain massifs that stretch for many hundreds of kilometres. One of these immense peaks is nearly 9,000 metres high. We do not have such high mountains on our planet. Seven of the lunar mountains are over 6,000 metres high and 28 exceed 5,000 metres.

All the lunar mountains are heavily fissured and extremely precipitous, and there is a wild, compelling beauty about them. But even against the background of these mountains there is an astonishingly straight wall, a perfectly straight mountain range with almost sheer sides. It looks amazingly like a titanic artificial barrier erected by giants against powerful enemies. But the cirques and craters are unquestionably the most interesting feature of a photograph of the Moon. They make the lunar surface different from any of the landscapes we have on Earth. These cirques, some of which have a diameter of scores of kilometres, stir up the most fantastic flights of fancy.

In many places the lunar surface contains deep fissures with sharp, abrupt edges, resembling the cracks that sometimes form in the plaster on walls or narrow canyons hewn in mountains by swift rivers. But our terrestrial canyons are much shorter than the lunar fissures, which are usually over 100 kilometres long and hundreds of metres wide and deep.

Some of the depressions on the lunar surface are several kilometres wide and their walls are not very steep. Astronomers call them furrows, some of which bear a startling resemblance to the channels of dried-up rivers. Some scientists assume that at one time water washed these lunar valleys, canyons and ravines.

A stunningly beautiful picture is formed by the long bright rays fanning out for hundreds of kilometres from some of the craters. They pass across the sides and floors of the craters, climb over mountain ranges and run along

the low-lying plains, nowhere deviating from their course. They give the impression of being the handiwork of an artist who used a huge brush to leave a memorial to himself in the shape of a pattern of perfectly straight lines.

What does this "inscription" on the lunar surface mean? Who made it? What dreadful catastrophes took place in the lunar expanses and left this indelible trace? These questions bring us to our old friend's most closely guarded secrets. Let us try to penetrate them.

... ITS MYSTERIES

The Moon has many secrets. For many long decades attention has been riveted to the problem of the Martian canals, which seem to have been dug by intelligent beings to irrigate their arid planet. Year after year astronomers sought to get a glimpse of Venus's surface through the blanket of cloud around her. For centuries scholars have been trying to unveil the mighty laws that gave Saturn its resplendent rings.

But the riddles of the Moon do not pale even beside these baffling mysteries. Where did the Moon come from? How did its extravagant landscape take shape? Is it a dead, an irrevocably extinguished heavenly body or are mighty forces still active beneath the thin surface crust? Is the Moon cold or hot? Is enigmatical life nestling at the bottom of the deep fissures?

Yes, the Moon has many secrets.

Riddle No. 1

A FRAGMENT OF THE EARTH?

A huge, white-hot, dazzlingly brilliant, semi-fluid sphere raced in the boundless spaces of the Universe. The raging protuberances of the Sun stretched out towards it like the

fiery paws of some colossal monster eager to seize and swallow it. But even more terrible and relentless were the forces of gravitation, which set in motion mighty tidal waves that slowed down the rotation of this semi-fluid sphere. Submitting to the immutable laws of Nature it gradually lost its symmetry, first turning into an ellipsoid and then acquiring the shape of a gigantic pear. Acceding to the mighty forces of gravitation, this pear kept stretching, its "waist" growing thinner until, rent by the Sun, it separated into two unequal spheres.

Such is the picture George Darwin, the eminent English astronomer and mathematician, draws of the birth of the Moon, of its "detachment" from the Earth. After breaking away, it stopped at a distance of 15,000 kilometres and began to revolve round the Earth, taking four or five hours to complete each revolution. This happened only 4,000 million years ago.

But even after this overwhelming catastrophe, the forces of gravitation went on tormenting the Earth and the Moon. Giving rise to tides and helped by the reciprocal gravity pull of the Earth and the Moon, they continued slowing down their rotation.

As the lighter body, the Moon was more submissive. Unable to resist, it stopped, turning one side to the Earth and for ever hiding its reverse side. The Earth continues to resist to this day, but it too is slowing down, prolonging its day by 1/1,000th of a second per century.

Darwin substantiated his theory wonderfully, but in spite of that Soviet scientists found that his computations contained vital errors, which cast a doubt on this seemingly convincing picture.

The noted Soviet scientist Otto Yulevich Schmidt advanced a fundamentally different hypothesis. He believes that the Moon was formed at the same time as the Earth from a meteor-dust cloud surrounding the Sun. This cloud solidified, the particles in it colliding, merging, again

splitting and again merging until finally more massive condensations formed that gradually absorbed all the matter in the cloud.

Who is right–Darwin or Schmidt? Most scientists are inclined to accept the less spectacular but more convincing theory suggested by Schmidt. But to this day the birth of the Moon remains a mystery.

Riddle No. 2

CURIOUS POCK-MARKS

One cannot fail to be puzzled by the fantastic riot of Nature–the chaotically piled rocks, the phantasmagoria of cirques and craters, the weirdly zigzagging fissures and the arrow-straight rays–that strikes the eye even at a first glance at a photograph of the Moon. What forces brought this mystic landscape into being? Regretfully we are still unable to answer this question exhaustively. Arguments rage even over the origin of our own, terrestrial mountains despite the fact that we can climb them whenever we like, make any collection of the minerals of which they consist and, lastly, drive tunnels, mines and wells into them.

Perhaps the only point on which all selenologists concur is that the various sections of the lunar surface took shape at different times. Some are older, others younger. That is seen best of all on the example of the mammoth Cladius Crater, which has at least 20 smaller craters on its sides and floor. Obviously, they appeared when the parent crater was already in existence.

Many scientists are inclined to believe that the lunar seas formed later than the continents or, to be more exact, that they took the place of continents. Influenced by Cyclopean forces portions of these continents together with

their mountain ranges and cirques sank and were inundated by a dark substance such as lava or magma.

But the origin of the ring mountain systems–the craters and cirques–remains the most debatable issue. Some scientists hold that they were made by earthquakes and the eruption of volcanoes. Others categorically insist that they are traces of enormous meteorites that hit the Moon. The computations of the Soviet scientists K. P. Stanyukovich and V. V. Fedynsky confirm that possibility. P. F. Sabaneyev has even tried to check this theory experimentally. He dropped powdered chalk on to a layer of similarly powdered chalk and obtained miniature craters that were amazingly similar to the lunar craters.

What then caused these craters? Eruptions or the impact of meteors? Perhaps both? A piece of the Moon brought to Earth would help to settle this argument. In the meantime the debate goes on.

Riddle No. 3

TWO FACES OF ONE SATELLITE

The forces of gravity have turned one side of the Moon towards the Earth and for ever hidden the reverse side. However, the Moon does not rigidly hang opposite the Earth, but oscillates slightly, from time to time showing sections of that obscure reverse side. Thanks to this oscillation or, as astronomers say, libration, scientists have studied nearly 60 per cent of the Moon's surface. But until a few years ago nothing at all was known about the remaining 40 per cent. No human eyes ever saw it and the most fantastic theories were put forward.

Some people went so far as to assert that this "other half" was non-existent, that the Moon was a hemisphere and that was why only one and the same side faced the Earth.

These arguments were settled by a wonderfully accurate cosmic experiment. A Soviet interplanetary station flew round the Moon, photographed its mysterious half and transmitted the photograph to Earth.

As could have been expected that "other half" exists. Fundamentally, it resembles the face of the Moon that we know so well. But there are many features about it that we cannot yet fully explain. Most of the unseen side (nearly 90 per cent) is occupied by mountains. There are considerably fewer dark spots or "seas" than on the visible side. And there are very few craters. The side facing us has nearly 50,000 craters, while the unseen side only a few. Why?

Why is the difference so great between "two sides of the same coin"? What caused such a sharp distinction in the most salient feature of the surface of our satellite? The answers that have so far been attempted are unconvincing. This riddle remains to be solved.

Riddle No. 4

ENIGMATIC PHANTOMS

These are not shades of the dead, nor are they apparitions or ghosts dancing over graves. They are existing, real phantoms.

In many places of the lunar surface the "living" craters, surrounded by walls casting shadows, are adjoined by mysterious spectre or phantom craters. At a first glance they give the impression of being ordinary lunar ring formations. But a closer look shows there is something unnatural about them. Their ring walls can scarcely be made out and the most remarkable thing about them is that they do not cast shadows. All that can be distinguished is a pale, vague ring against the background of a sea.

Hence the name phantom. From legends we know that only phantoms do not have a shadow.

But legends apart, if we hold strictly to the laws of optics we shall find that the only objects that do not cast a shadow when oblique light falls on them are those that do not tower above a surface. Consequently, the walls of the craters must be lower than the surface of the sea and are seen in the same way as shoals can be seen from an aircraft.

However, we must remember that there is no water in the lunar seas. But is the rocky matter of the lunar plains translucent? That is hard to believe. True, the Soviet scientist Professor Sharonov thinks it possible that a light melted substance from the crater was mixed into the thin layer of dark lava on the top of the wall. It "diluted" the lava, giving it a lighter colour, thus explaining why the crater's "burial" is marked by a phantom.

Sharonov's surmise may be correct, but many selenologists do not agree with it. It is therefore too early to regard the riddle of the phantom craters as solved.

Riddle No. 5

LIGHT RAYS

In the Moon's Southern Hemisphere, near the Sea of Clouds, is Tycho, one of the largest of the lunar craters. Its size is not all that attracts attention. Even a small telescope will show an amazing pattern of more than 100 linear light rays radiating from it. They remind one of a regular network of meridians painted on the crater as on a pole. Around the wall of the crater there is a dark zone into which the rays do not penetrate. They begin some 60 kilometres from the wall and, fanning out, run in straight lines without affecting the relief of the moonscape. They extend over enormous distances. One of them

is over 1,500 kilometres long, while another, according to some computations, is nearly 4,000 kilometres long.

Rays are also observed near Copernicus, Kepler and other craters, but there they curve and intertwine, sometimes forming dense networks.

What are these rays? Scientists have been arguing about them for a long time. Some consider they are volcanic ash ejected during the eruptions that formed the craters themselves. Others believe they are crevices that were formed during tectonic processes and then filled by light-coloured lava rising from the bottom. Still others, supporters of the theory that the craters are the result of meteoric bombardment, categorically maintain that the rays took shape as a result of the sedimentation of dust that was blown into the air by the impact of meteors and then slowly settled in the direction of the powerful impact wave.

Argument, it is said, gives birth to truth. But so far it has been barren.

Riddle No. 6

IS THE MOON BLACK?

Kozma Prutkov* said that if on an elephant's cage you read the inscription "buffalo", do not believe your eyes. He was quite right. And if you find the Moon very bright, do not believe your eyes. Do not believe them even if through a telescope the lunar surface seems to be blindingly white.

This whiteness is due to the bright sunlight flooding the Moon. Under these conditions even black velvet will seem as white as new-fallen snow.

Indeed, accurate measurements show that the lunar surface reflects only seven per cent of the light received by it. This means that the lunar surface consists of extremely dark matter resembling dry black earth, wet loam or rock of the

* Pen-name of the nineteenth-century poets A. K. Tolstoi and the three Zhemchuzhnikov brothers – *Ed.*

basalt or diorite type. There is no snow or ice on it as some German scientists surmised. Moreover, the widespread opinion that the lunar continents consist of granite must be regarded erroneous because the colour of granite is much too light. If we assume that the lunar surface is composed of rocks similar to those found on our planet, we must confine our search to the blackest of them.

But are they rocks? Here we approach another puzzle.

Riddle No. 7
ON DUSTY TRAILS

A song liked by cosmonauts has the following words:

"On the dusty trails
of distant planets
We leave our tracks. . . ."

The Moon will most likely be the destination of man's first interplanetary journey. But whether tracks will be left on the lunar trails is quite a different matter.

What are these trails "made of"? What do we know about them? First, that the lunar surface is extensively furrowed and disfigured by sharp, angular irregularities. This has been discerned by the way light is reflected from the lunar soil. On the other hand, radio waves are reflected from it as from a perfectly smooth sphere with a mirror-like surface. Consequently, these irregularities are longer than light waves but shorter than radio waves. In other words, their size is a matter of millimetres.

Moreover, the substance of which the lunar surface consists is a poor heat conductor and must therefore be either porous or extremely loose. Almost all scientists agree on this point. But further on their opinions clash.

Some consider that at one time the Moon had moisture

and a rarefied atmosphere and that the lunar soil was formed in the same way as our deserts, as a result of erosion.

The partisans of the volcanic theory of the origin of the lunar relief are inclined to believe that lunar soil consists of settled volcanic dust.

But there is another opinion that regards this dust as of cosmic origin. As a matter of fact, fairly simple computations indicate that the large quantity of cosmic matter settling on the Moon is so large that in the course of 1,000 million years a layer one centimetre thick could have covered the entire surface.

Yet all these hypotheses must be regarded as extremely doubtful. In many ways they contradict the data now available to us. No matter how alluring it might be to leave tracks on the dusty lunar trails, it is highly questionable if that is possible. We now have fairly convincing data to show that the surface of the Moon consists not of dust but of a porous substance resembling slag One way or another, this puzzle still awaits its solution.

Riddle No. 8

IS THE MOON HOT OR COLD?

Not "or" but "and"! Today that would be the only correct answer to the question of the temperature of our satellite. In sunshine its black surface is heated to a very high temperature, but when it lies in shadow severe frosts reign supreme.

The lunar day is two weeks long. During that time the Sun makes the surface red-hot but the two-weeks' night allows it to cool sharply. Besides, the Moon has no atmosphere, no air jacket such as covers our Earth and saves it from the "fever" that unrelentingly torments our satellite.

Computations show that when the Sun reaches its zenith over the Moon, the temperature there rises to 119°C. With the help of sensitive modern astronomical instruments it has been found that these computations are close to reality. During a full Moon the temperature at the hottest point of the lunar disk, in its very centre, reaches 134°C. In the area between the centre and the edge the temperature rises to 122° and along the rim it does not exceed 67°.

But when the Sun sets the part of the Moon that finds itself in shadow cools rapidly, the temperature falling by 200°, probably dropping in some places to 150° below zero. Similar temperature variations take place during lunar eclipses.

It seems we know everything about the temperature of the Moon, and about what takes place during the lunar day, night and eclipses. What, then, is the puzzle?

The whole trouble is that all our knowledge about the Moon's temperature concerns the surface. But what is the temperature in the body of the Moon?

Riddle No. 9

IS THERE LIFE ON THE MOON?

No secret existed on this score until recently. Nobody thought it worth arguing about the possibility of life on the Moon. The conditions on our satellite are so unfavourable for life that there was almost no hope for an affirmative answer. Yet....

Some time ago the astronomer Patrick Moore noted dark radial strips on the floor of Aristarchus Crater. These strips grew longer and then became shorter again as though they were the feelers of some fabulous monster. Similar "moving" strips were observed in at least 20 other craters. Besides "moving", they changed their colour, turning into a hardly perceptible greenish-brown. At the

height of the lunar day (remember it lasts for two weeks) they lengthened out and became more noticeable. But towards "evening" they faded, "shrivelling up".

Of course, they are not feelers of an animal. That is quite out of the question. But could they be vegetation? Difficult as it is to believe that there is life on the Moon it is similarly difficult to discount this possibility altogether.

Radiotelescopes have shown that in some regions the temperature fluctuates within a much smaller range than on the greater part of the surface. It is only 30°C during the "day", while at "night" the temperature does not fall below −75°C. That is the temperature range in Yakutia. Besides, the possibility of there being at least an inconsiderable amount of water on the floor of some of the lunar fissures must not be excluded.

But there is no atmosphere on the Moon, sceptics may argue. That is true. But neither is there an atmosphere in the deep ocean depressions or in the top layers of our planet's gas jacket. Yet one finds life there.

Another argument that sceptics put forward is that because the lunar surface is not protected by an atmosphere it is virtually flooded with lethal short-wave radiation. However, bacteria have been found to be living and multiplying in the waste from the atomic reactor in Los Alamos, U.S.A., where the radiation intensity is 2,000 times the dose that would be fatal for man.

So what is the answer? Is there life on the Moon? For the time being that is a mystery.

Riddle No. 10

IS THE MOON'S DESTRUCTION INEVITABLE?

Yes, the Moon will perish. Disappointing as it is to lovers and poets, the days of our lovely satellite are numbered, cosmically speaking, of course.

George Darwin, who attempted to explain the origin of the Moon, and Harold Jeffreys have forecast that ultimately the Moon will be destroyed. Gravitational attraction to which we owe our tides will slow down the rotation of the Earth and the Moon, lengthening our days and months. The Moon will move ever slower along the visible vault of sky until one day it will hang motionless over some one spot of the Earth's surface. It will remain in that position for a long time, adorning the sky over one hemisphere and never appearing in the other.

The period of rotation will be equal to 55 of our present days, and the Moon will draw 1.6 times farther away from the Earth.

This will be followed by a long period of equilibrium, but gradually solar-induced tides will again shorten the day and the Moon will begin to draw nearer to the Earth. When the distance between the Moon and the Earth will be equal to 2.5 times the Earth's radius, the forces of terrestrial gravitation will be large enough to shatter the Moon into fragments.

The Moon's destruction will not affect the Earth, for the fragments will not reach it. They will continue to describe orbits and, perhaps, be crushed into smaller fragments by collisions to form a radiant Saturnalian ring.

In the distant future the nocturnal sky may perhaps be even lovelier than it is today. It is a pity that we shall not be there to see it, because the destruction of the Moon will take place not earlier than in 1,000 million years.

If, of course, it will perish at all, because much in the hypothesis put forward by Darwin and Jeffreys is still unclear.

Vladimir Lvov

COMMUNITY OF WORLDS

Matter-life-intelligence. Planets of distant stars. Astrophysical forecasts. 12,000 million seats of intelligence. Counting 1,000 millenniums as one year. Meeting elder brothers. The Great Ring watch

Ours is an old problem, which has been stirring man's imagination since the dawn of history. Today it attracts renewed attention.

If man has set his mind on penetrating deep into outer space and preparing to make the stellar worlds a field of activity then is it not inevitable that humanity will one day come into contact with intelligent beings of other worlds?

The time has come for this problem to be analysed thoughtfully and its consequences weighed and assessed.

But first a few basic facts.

What data does science have to show that there is other intelligent life in the Universe?

The following is a very general answer to this question, which was put a long time ago. The Universe is one and in it matter develops, passing through the same qualitative stages. Life appears from wherever the necessary conditions obtain. As it develops it engenders intelligence, which is its highest stage. In its turn intelligence is founded on the matter of the brain, which is the most precious of all matter in nature.

But where can we count on finding seats of intelligent life in the Universe? Where must we look for them?

Astrophysics, the science treating of the pattern of development of stars, has recently come upon firm evidence providing an answer to this question.

Let us begin with the fact that in order to develop life must have warmth and light. The most favourable temperature for life-developing protein ranges from 10 to 40°C. This temperature obtains on some of the planets. A planet must revolve not very far from and yet not very near to the luminary giving it warmth. Otherwise the icy cold or the burning heat will destroy the shoots of life. In our solar system, the Earth is perhaps the only planet moving in what may be called the "zone of comfort" for life. But our Sun is only one of myriads of suns in the Universe. They are stars. And there must be planets around them.

With a certain degree of confidence astronomers can now name the stars that are the most likely to have a suite of planets. There are a countless number of these stars in the Milky Way.

Some time ago a remarkable discovery was made by the American astronomer Otto Struve, who based himself on a feature of our solar system that had long been attracting the attention of scientists. The Sun, which had seized the lion's share of the mass of our system—it is 1,000 times bigger than all the planets put together—has, at the same time, been cheated out of rotational motion. It revolves on its own axis slowly, completing a revolution in 27 days. The reason for the slowness is that almost all the rotation has gone to the planets. It has been calculated that if the sum of rotational motion by the planets were to be transferred to the Sun it would revolve on its axis fifty times faster than at present.

Otto Struve decided to find out the rotation velocity of stars of different types. The axial rotation of distant

luminaries was first measured by the famous Russian astrophysicist Aristarkh Belopolsky more than half a century ago. Since then many new facts have been brought to light. When Struve began his experiments his findings astonished and excited astronomers. He divided the stars into two approximately similar numerical groups. The first were luminaries revolving exactly as our Sun. The second consisted of stellar "tops", which rotated about 50 times faster. There were no gradual transitions. The rotation was either like that of our Sun or 50 times faster! Unavoidably the implication is that the stars of the slower moving group have planetary systems. If this conclusion is correct (all the latest data indicate that it is), then about half of all the stars of the Milky Way are surrounded by planets. This provides a reliable foundation in the search for life in the Universe.

Indeed, the "raw materials" for life exist throughout the Universe. They are hydrogen, carbon, oxygen, nitrogen and other elements and they are to be found everywhere: in the dark and cold nebulae of inter-stellar dust and gas, from which stars and planets are formed. All these nebulae, as has been recently ascertained, contain water, carbon dioxide, methane and ammonia (in the shape of pieces of ice). In addition, they probably contain more complex matter, which may be considered as real "half-finished products" of life. They are what we call polypeptides, the tiny bricks of which the more complex proteins are built. Traces of polypeptides have been found in some of the meteorites that landed on the Earth. They were undoubtedly formed in the nebulae of cold cosmic dust, as a result of collisions and the gradual development of simple particles of matter. As soon as a star with a system of planets arises, the "ferment" of life appears on it. Today science no longer doubts that in the Universe life (at least in its simplest forms) is as natural a state of matter as, say, gas

and dust between stars, as the molten matter of stars, as the cold crust of planets.

But this gives rise to a crucial question. The simplest forms of life have to travel an enormous distance from lumps of protein mucus to intelligent beings. What are the chances that this distance has been covered somewhere else, besides the Earth?

The history of life on Earth, from protein molecules to man, embraces a period of at least 4,000 million years. The requisite for this was, chiefly, the uniform and constant light from the Sun. If throughout this period the Sun shone unevenly, with sharp fluctuations (a feature of many stars), life would not have progressed far on Earth. Evolution would have stopped, leaving behind either frozen or overheated corpses of living beings. Hence not every star can provide a haven for highly-organised life. A luminary is needed that would shine with an even and sufficiently powerful light for many thousands of millions of years. Astronomers have carefully selected the stars that satisfy this requirement. It was found that about six per cent of the stars of the Milky Way could ensure suitable conditions for the evolution of life (our Sun is one of these stars). The most remarkable feature is that most of them revolve slowly. That, as we have already pointed out, is a sure indication of the presence of planets.

These six per cent are stars where we can expect to find intelligent life. What does this percentage come to numerically? In the Milky Way there are about 200,000 million luminaries. Six per cent of this number gives us 12,000 million, which means that possibly in the Milky Way there are 12,000 million human worlds like ours.

But where are we to look for them?

Three weakly radiant points among the stars twinkling in the night sky are today attracting special attention. They are Epsilon Eridanus, Epsilon Indus, and Tau Cytus. Even the most cautious sceptic cannot help admitting their

startling resemblance to our Sun. Their mass and size are almost the same as that of the Sun. But the distance of 11 light years (one light year is about 10,000,000 million kilometres) reduces them to modest stars of the fourth magnitude. Our bright Sun presents the same picture for those who perhaps gaze at the sky from one of the planets of Epsilon Eridanus or Tau Cytus.

Do they suspect that we exist and are thinking of them? Or perhaps a countless number of civilisations have reached a high level of development and learned to communicate with each other?

If that is the case the inclusion of our terrestrial civilisation into this chain of friendly relations is only a matter of time.

I said friendly relations. There is every reason to suppose that contact between societies of intelligent beings cannot be anything but friendly co-operation.

What is this confidence based upon?

Primarily on data obtained by astrophysicists.

Our luminary and our planetary system, including the Earth, are relatively young, approximately 5,000 million years old. Our Sun has at least another 50,000 million years of existence before it. The age of stars, it must be pointed out, is quite accurately computed in accordance with their content of hydrogen, which is the lightest chemical element. The history of the stars is a history of the gradual burning away of hydrogen, naturally not simple combustion but a nuclear reaction in which hydrogen turns into helium.

Young as the Sun and Earth are, mankind is immeasurably younger. The first human beings appeared about 1,000,000 years ago. Of these million years at least 990,000 were occupied by primitive savagery, slavery and feudalism, by pre-scientific myths and the infancy of science.

This state of affairs has been wittily described in figurative form by Professor John Bernal, the noted British scientist and peace fighter.

For the sake of clarity he introduces a new time scale, suggesting that one year be counted as 1,000,000. Secondly, he begins his count from 12 o'clock, from noon. Under this new, conventional time scale, mankind appeared "a year ago". Farming emerged "a week ago". The first hieroglyphs were invented "the day before yesterday". A written language was devised "yesterday". Columbus discovered America "today at 7 o'clock in the morning". The steam engine was invented "at 10 o'clock in the morning". The telegraph and the telephone appeared "at 20 minutes to 12". The radio and the automobile were invented "at 25 minutes to 12". Atomic power was used for the first time "at 6 minutes to 12". And, lastly, the first sputnik was launched "a minute ago". That was in the past. While ahead of them, the Sun and the Earth, and, consequently, mankind have, counting time by the Bernal scale, another 45,000-50,000 years.

We thus get a clear-cut picture. Compared with our planet's past and future history, the epoch of mankind's childhood is a tiny fraction—1/50,000th—of time (a million out of 50,000-55,000 million years).

The period of transition to modern history is even shorter. For example, less than half a century separates the present, when the socialist camp unites more than 1,000 million people, from the day the October Revolution triumphed.

One way or another, the period of the present social (and, simultaneously scientific and technical) leap, will occupy 1/500,000,000th of the past and future history of our planet. But the shorter the period of development the less chance is there of finding in the Milky Way a

civilisation going through the same period of development.

The legion of stars contains luminaries of all ages. A simple calculation shows that of the several thousand million possible seats of intelligence only a few complete their transition from infancy to maturity at each given moment. A somewhat larger number of societies is in a state of infancy, in a state lacking the technology, the mature science or the level of thinking necessary for participation in cosmic communication. Lastly, the overwhelming majority of civilisations, according to the calculus of probability, have undoubtedly achieved the highest stages of social harmony and technical might. We shall most probably come into contact with these developed civilisations, who are our "elder brothers" in spirit and intelligence. Consequently, the prospect of such an encounter is not disquieting. On the contrary, it is something we can look forward to with the greatest of optimism.

That is precisely how Konstantin Tsiolkovsky argued. "In our swift progress," he wrote in 1924, "we shall meet many new worlds of intelligent beings, infinite gradations of generations who have achieved a higher level of development than man and even his most highly developed descendants. Is there any doubt that they (seats of intelligence in the Universe) have established contact among themselves? Is there any doubt that their social organisation is superior to anything we know of today? It is beyond our power to picture their might. It seems inevitable that one day they shall influence terrestrial life...."

In the novel *Andromeda,* Ivan Yefremov, the Soviet writer and scientist, speaks of mankind's dream of being received into the cosmic fraternity of intelligence, of a

federation of happy and free societies populating the islands in the Universe.

Taking us five or six centuries into the future, *Andromeda* describes events that "ushered in a new era in the existence of man". An Indian scientist named Kam Amat received the world's first intelligent signals from outer space. They came from the double star Cygnus 61 and were decoded with the aid of logical and translation computers. These signals from Cygnus 61 (to which other signals were soon added) were notices of the existence of a "Great Ring" or a community of planets in the Universe. The intelligent beings of the solar world were asked to join this "Ring".

This is fantasy, of course, but it sounds like a far-sighted scientific forecast. Its attraction lies in its faith in the triumph of intelligence as a material force studying and transforming the world.

For mankind, Yefremov maintains, the "era of the Great Ring" will signify more than the broadening out of scientific knowledge and a technical revolution linked up with "the Earth's contact with the life, work and ideas of other populated worlds". The "Ring era" will cause a revolution in mankind's social thinking. The Earth will become a member of the community of intelligent forces of the Universe. People will be regenerated spiritually and morally, "and join their brothers in intelligence in a single, infinitely happy family".

One may disagree with Yefremov on one point or another. One can dispute his interpretation of various aspects of the future. The idea of a "Great Ring" is, I repeat, more than literary fantasy. It is a sphere where imagination merges with scientific prevision. Development is likely to be so rapid that the events described by Yefremov may take place much earlier than in the twenty-fifth century. The rate of scientific progress may outpace the

boldest forecasts and expectations. In any case, Ivan Yefremov could hardly have expected that radio astronomers would be keeping what may be called the "Great Ring watch" only three years after the publication of his novel.

Yet that is what has happened. Some time ago one of the world's major radio observatories headed by Professor Otto Struve began systematic probes in the region of Epsilon Eridanus and Tau Cytus.* These two stars, which are relatively near our Sun, are regarded by astronomers as the most promising. If intelligent beings live in the vicinity of these stars it is possible that they are sending radio signals in the direction of our Sun. Further, it is natural to suppose that these signals are being transmitted on wave-lengths in the 1,000-10,000 megacycle range, which least of all suffers from disturbance in planetary atmospheres and in inter-stellar gas. Can radio waves be received over such long distances? The latest developments have made it possible. Giant radio-telescopes have been built. The world's largest mirror-antenna is under construction near Moscow. Moreover, due in large measure to recent researches by the Soviet scientists Basov and Prokhorov radio engineering now has supersensitive amplifiers. Assuming that our stellar neighbours are using generators of the same capacity as ours, radio communication could today be established over a distance of up to 15 light-years. Epsilon Eridanus and Tau Cytus are situated within this range. However, there is the circumstance that radio waves travel at the same velocity as light. This means that we have to wait 20 years for an answer to every message. That is a "little" slow! Nonetheless it would not rule out communication.

* These experiments had to be discontinued because the American radio-telescope in Greenbank, West Virginia, failed to reach the capacity planned for it.

Thus, radio communication with islands of intelligence in outer space has now become a realistic scientific task. Scientists are discussing this problem, giving their opinions and suggesting various methods. In an article published in the scientific journal *Nature,* the physicist Braswell analyses the steps that may be taken by possible inhabitants of Epsilon Eridanus and Tau Cytus if their technical level is higher than ours. In that case, Braswell says, they will most likely attempt to send containers with automatic apparatuses to the solar system. He has in mind cybernetics instruments that can take their bearings independently, adopt logical decisions and send messages. Another possibility, Braswell writes, is that such containers are already travelling in the solar system and sending coded radio signals. He ends his article with a plan of how to look for and decode such signals.

An even more tempting idea is advanced by the physicist Freeman J. Dyson He speaks of the so-called "reconstruction" of the planet Jupiter. He believes that this work will lead to the building of a kind of cupola or "sheath" round the Sun. This, he says, is the kind of work a sophisticated civilisation of any planetary system must inevitably accomplish. Its purpose is to make the maximum use of the radiant energy of the stars. According to this hypothesis, each society of intelligent beings will sooner or later surround its central luminary with an opaque cupola, giving rise to what Dyson calls a "point source of infrared rays". He suggests that astronomers should look for (invisible) "point sources" emitting waves in the 10-20 micron range. The discovery of at least one such source would pinpoint a possible seat of intelligent life. Once that is done, Dyson says, thought could be given to establishing radio communication with it.

It goes without saying that there is still no firm foundation for all these daring plans and hypotheses. We must remember that we are in the earliest stage of space

exploration, a period of trial and error. This stage in not even a prologue, but the prologue to the prologue of the coming epoch of space communication.

However, the rise of that epoch is objectively inevitable.

"I believe that a marvellous future awaits mankind," Konstantin Tsiolkovsky wrote. "I am confident that man will go farther than inheriting the Earth.... From here, from the solar system, he will reach out to the whole of the Universe. I am profoundly sure of that."

SAAREMAA

SCIENTISTS UNRAVEL MYSTERIES

THE SECRET OF SAAREMAA ISLAND

TOWN WITH A DOUBLE BOTTOM

L. Kuznetsov and I. Yevgenyev

THE SECRET OF SAAREMAA ISLAND

Autumn of 1927

Two roads—Pikkjalg (Long Leg) and Lühikejalg (Short Leg)—lead to the steep hill called Toompea. The first is a level road along which one can travel easily. The second is more like a ravine and has to be climbed.

The citadel of Toompea was built by warlike knights in the Middle Ages. A town with gable-roofed houses and narrow streets appeared at the foot of the citadel. The years passed by. Early in the twentieth century the massive buildings and the shell-pitted towers were turned into government offices. One of them was the Mining Department.

One sunny morning in September 1927, an unusual morning because in Tallinn the autumn is a rainy season, two men made their way to the Mining Department at one and the same time. They were the Department's director Kuusalu and a geologist named Reinvald.

Reinvald had just returned from a distant expedition. He eagerly inhaled the air as he looked about him, seeing evidence of his work everywhere. The shining, bright-gray tiles of a new house reminded him of the frowning quar-

ries near Vasalemma. The blue tiles on the roofs brought back memories of the Gulf of Finland where he found deposits of blue clay. The staircases were made of a tough limestone that he had discovered.

Kuusalu, too, was engrossed in thought. His mind was on salt and Saaremaa Island. For many months his attention had been rivetted to Lake Kaali on that island.

The dispute over the lake's origin had been raging for a hundred years. Many opinions and hypotheses had been offered. But no real solution had been found because no scientist could prove his theory. When many researchers were inclined to regard this problem as unsolvable Kuusalu put forward his own hypothesis. The lake, he said, was a hollow carved out by water in saline soil. It was simple and natural. But the hypothesis had to be verified. Kuusalu needed proof and there was no time to be lost.

When he got to his office he sent for Reinvald.

The geologist answered the summons promptly and began his report on the results of the summer expedition. Kuusalu cut him short.

"Just a minute, Reinvald," he said unhurriedly, "I have a surprise for you. It's something a geologist can only dream of. A firm, mind you, a foreign...."

"Again foreign," Reinvald said, puckering his brow.

"As a matter of fact, the nationality of the firm does not concern you or me," Kuusalu said, noting the geologist's vexation. "The important thing is that they want to develop the salt deposits. You appreciate what that means, I suppose? The firm came to me for assistance. I have in mind deposits lying almost on the surface. Exactly. Near Lake Kaali on Saaremaa Island. I've planned everything. You'll go there, say, tomorrow or the day after and look it over. Strike while the iron is hot. That, I think, is what folks say in the circumstances. Trust my experience—the foreigners will not leave us out in the cold. The salt will turn into marks and dollars before our eyes."

Reinvald did not know what to make of it. The whole of Estonia was as an open book to him. He knew her like he knew his own house and the contents of the drawers in his desk. To him she did not seem as small as to travellers in a train. The reason was, perhaps, that he did not travel about the country in the ordinary sense but walked and sometimes even crawled. True, he had never been on Saaremaa. But neither the professors at his institute nor any of the geologists he knew ever said anything about there being salt on the island. Naturally, he'd have to check that. But what was the hurry? Why did he have to go at once, now, when winter was approaching and the rains would start in a day or two? However, it was against his rule to ask Kuusalu questions, and least of all to question orders. He left the director's office with his mind full of doubts and conjectures.

In the autumn of 1927 the Director of the Mining Department signed the order commissioning the geologist Reinvald to go to Saaremaa Island without delay.

REINVALD MAKES UP HIS MIND

With the dust from the long summer's expedition still clinging to his shoes, Ivan Reinvald found himself packing for a journey again. His team of bearded workers filed into the house before Lydia, his wife, could tell him the family news.

Had it been anyone else, his foreman Lillo and three workers would hardly have agreed to go out on a job at this time of the year. But like other men who had worked with Reinvald they had come to like and admire him.

On a drab day that autumn Reinvald set out from Tallinn for Virtsu Bay. His route to Saaremaa Island lay across Muhu Island.

A gusty wind was blowing and waves slapped the deck, splashing over Reinvald's feet where he stood in the stern.

Muhu Island came into sight. The zigzagging, craggy shoreline was only slightly above sea level. It seemed that the sea was poised to inundate the entire island with its fields, pastures and homesteads.

The ferry boat grated on the shore. Reinvald and his team boarded a shabby bus that took them along the even, gravel-strewn road. Muhu reminded Reinvald of a school exercise-book. The island was ruled into a multitude of tiny squares. The rock debris cleared from the land was piled along the sides of the roads, the edges of the fields and meadows, around the homesteads and the fringe of the forests, giving the island its chequer-board look.

Saaremaa, too, was a low-lying island with numerous bays, crooked capes and tiny peninsulas. As on Muhu the tiny fields were covered with juniper, and there were miry, grass-overgrown swamps and cheerless boulders. The land, bordered as on Muhu with "stone walls", gave little in return for the back-breaking labour put into it.

Towards evening the bus arrived in Kuressaare (Kingisepp), and on the next morning the team marched off towards Lake Kaali.

A high, steep bank of rock towered in the middle of a desolate plain. Reinvald scrambled up to the top of the bank and looked down at a round lake with greenish water. Narrowing down at its base the bowl holding the lake resembled a Swedish turnip. Hence the name Kaalijarv, *kaali* being the Estonian for Swedish turnip, and *jarv* a lake.

Lake Kaali was deservedly regarded as the loveliest spot on the island. Oak, pine, birch and ash, which were reflected in the water, grew thickly along its sides.

The beauty of this peaceful landscape was marred by upturned lumps of dolomite, which seemed to say: "This was the scene of a cataclysm and we are its witnesses."

Yes, there was plenty of food for thought. For many kilometres around there was nothing but a flat plain, and yet here, in the middle of it, was a round mountain with a deep hollow instead of a peak. It gave the impression that Nature, which was stern and forbidding in these parts, had for the fun of it departed from its usual standards and created something special and unique.

Reinvald found lodgings for his team in a nearby homestead and, on the advice of the local schoolmaster, rented a room for himself in the homestead of a farmer named Otto Tuuling. With a board wall partitioning it off from the kitchen, it was a small room with nothing in it save a bed with a blanket made of tiny scraps and a table at the window.

"This suits me fine," Reinvald assured Tuuling's wife. "It's close to the lake. Besides, I shan't stay here long."

He did not suspect how many nights he would sleep on that bed and how many thoughts he would grapple with sitting at that table.

Next morning Lillo's sharp bore was already biting its way into the ground. Every day it went deeper, meeting only limestone and dolomite. There was no sign of salt. Soon Reinvald wrote in his diary: "We have reached a depth of 63.14 metres but have not found any salt. There is no gypsum here either, or anything that can be called clay."

The team could return home, but Reinvald kept delaying its departure. Every day when he passed Lake Kaali he could not help asking himself: "What is this? How is this deep hollow on an otherwise flat piece of ground to be accounted for? Who built this high bank round the lake?"

He tried to stop himself not only from thinking but also from looking at this curious lake. "I am not a scientist. I am an ordinary geologist," he kept repeating to himself, "I have a family to look after. I have just got myself out

of poverty and can't afford to spend my time on scientific problems."

Only a few years ago he had found himself without work. Under bourgeois rule that was not rare in Estonia On top of everything it was harder for Reinvald to find a job than any other geologist because in Tallinn they still remembered that in his youth he had been the leader of student gatherings and demonstrations at the Mining Institute in St. Petersburg. Fearing for his family he had given up politics long ago. But the factory owners had a tenacious memory for these things. And when Reinvald applied for a job he heard either a polite "Come again in a week" or the blunt "There's no work for you".

He shuddered at the thought of those years, when day after day he sought employment. His wife fell seriously ill and there was nobody to look after the three children.

Then, at last, fortune smiled and he was given a job at the Mining Department. Life became smooth for him. His wife recovered. So why should he destroy his happiness with his own hands?

But that accursed lake fascinated him, engulfing him as though he were a stone that had fallen into it.

Besides, his host Tuuling kept his interest awake with stories about the lake.

"It's the doing of Suur Tõll. What, you've never heard of him? I can scarcely believe it. Everybody on Saaremaa knows about Tõll. He was kind and strong. With one blow he could shatter a house. He could throw a spade on to a neighbouring island. And he could walk on water. A cart-wheel served him as a weapon. One day the island was invaded by a huge army. He seized his wheel and rushed at the enemy. With one swing of his wheel he felled many of the invaders. With another swing, many more of the enemy dropped to the ground. He swung the wheel for the third time, but it tore out of his grip and

lodged itself deep into the ground. A lake formed where it hit the ground."

In the evenings Lillo would come to the Tuulings. He would take a seat in the kitchen and begin from afar:

"Show me the man who would turn his nose up at gold. Take you and me. We are different people, but gold would not harm either of us. If I had it I would send my grandchildren to a university, to Tartu itself. While you would take your children for a trip abroad. And how happy that would make your wife. I'm not saying this for nothing. There's gold here. All we have to do is to dig for it. Ask Otto. He'll confirm what I say."

"Drop it," Reinvald said. "They're fairy-tales. I'd forgive an uneducated person. But you are a skilled worker."

"They're not fairy-tales," Lillo insisted. "Science is all right, but a mystery remains a mystery. At night with my own ears I heard mermaids laughing in the lake and gold jingling. I could not believe my ears, so I got up and went to the window. I saw a devil, as shaggy as a monkey, carrying gold out of the lake. It was brought to the lake from the sea, from sunken ships. Kaalijarv must have an outlet to the sea. How else would you account for the water in it rising and falling?"

Every evening Lillo brought some piece of news.

"Kaalijarv has no bottom," he whispered to Reinvald. "It never had one. Strings of stones have been lowered into it, but no bottom has ever been reached."

"People say a monster lives in the lake," he informed Reinvald on the next evening. "Many years ago the local baron ordered rocks to be thrown into the lake. He wanted to erect a memorial or statue or something. The peasants carried boulders to the lake. There're plenty of them on Saaremaa. But when they came back in the morning, the boulders were gone. The monster had swallowed them. At another time the same baron ordered one of the farmers to get some sand from the lake."

"Well, did he get it?" Reinvald asked.

"Yes, but he died that same night. The sand had a poisonous smell."

There seemed to be no end to Lillo's legends. He had quickly made friends with the local folk and avidly listened to their stories about the lake. As soon as he would go away his place would be taken by the schoolteacher Folma.

Naturally, he did not believe the tales about there being gold and devils in the lake and the lake having an outlet to the sea. But he had lived here for many years and had been observing the lake. Reinvald had to agree that it was an extraordinary lake. Reinvald, Folma insisted, had to get to the bottom of the mystery. He had to disentangle and read this extremely interesting page of the Earth's history.

Night fell. The teacher took his leave. The paraffin in the lamp over the table burned low. It had grown dark. But Reinvald could not sleep. He lay on the bed, but it seemed as though there were two men—the first keeping silent all day and waiting for night to fall to begin arguing with the second. One was enterprising, daring and inquisitive. The other was quiet, tremulous and cautious.

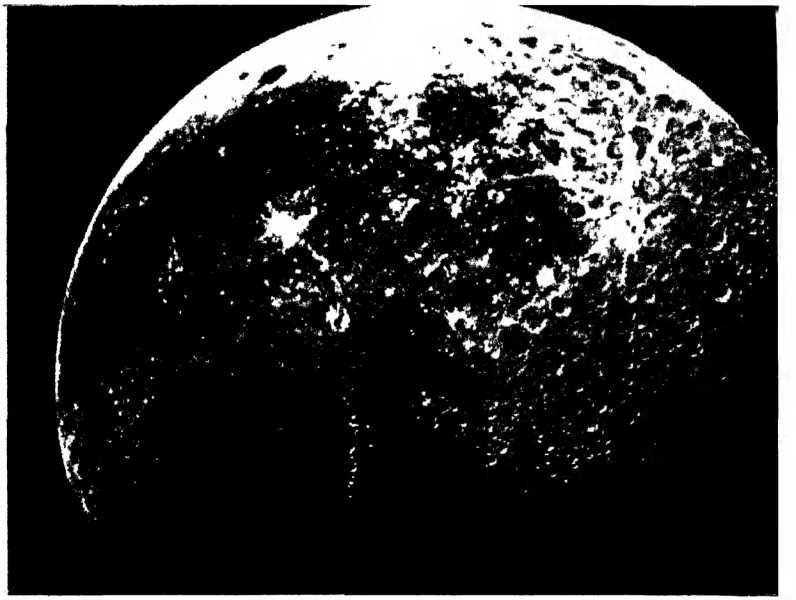
The first said: "Begin investigating the lake."

The second held back: "You're not authorised. Why stick your neck out?"

The first insisted: "Kaalijarv is a unique natural phenomenon. A true geologist cannot pass over it."

The second had his objection lined up: "Your family will be in a fix as soon as you try it. Remember what happened over that shale?"

...Some years before Reinvald had found himself in shale mines. In Estonia combustible shale had been discovered more than two centuries ago but it was mined by primitive methods. He felt that if this ocean of energy



Photograph of the Moon made with the horizontal solar telescope at Pulkovo Observatory

Lunar surface in region of the Nectar Sea

Archimedes, Aristillus and Autolycus craters on the Moon

Lake Kaali on Saaremaa Island

balance on a hastily rigged raft. That did not worry him for he hoped he would return to firm land a rich man.

Lillo had worked as a borer for many years. Reinvald had taught him to listen to the drive of the bore as a doctor listens to the throbbing of a patient's heart. By watching the bore he could now tell unerringly what lay in its path.

The bore touched something oozy. "Ha, the lake has a bottom, after all," Reinvald thought. "They were saying it was bottomless. That ends the first tale."

They took a sample. It was yellow crumbly alluvium that resembled a slippery jelly-fish. Its colour, remotely at that, was all that associated it with gold. "That's put paid to the second tale," Reinvald laughed, watching Lillo hold his nose—the smell of sulphur was coming from the alluvium.

The bore sank deeper. Soon it struck a harder stratum. They took another sample. It proved to be alluvium as well, but it was more solid than the first sample. The bore went ever deeper into the ground. Then it seemed to be going through a void. "Funny that there should be a hollow there," Reinvald thought. "Ho, the devil's treasure," Lillo said to himself. But there was nothing on the bottom except alluvium.

Lillo was completely wrapped up in his work. He did not notice that the rod to which the bore was fixed was beginning to bend. Reinvald was the first to see the danger and together they strained to draw the bore out of the lake. Only when they had pulled it out they saw they were ankle-deep in water. The raft was slowly sinking. With the heavy bore they just managed to reach the bank. Drenched to the skin and blue with cold they dragged their way home.

On the next day Reinvald carefully measured the depth and size of Kaalijarv and also the height of the rock bank surrounding the lake. He wrote in his diary: "Depth of

the lake: 16 metres. Diameter: 110 metres. Height of the bank: 7 metres." With the same thoroughness he investigated six of the neighbouring hollows, which the local inhabitants called "dry lakes". He named them craters.

From time to time the teacher Folma ran to Reinvald, reporting:

"The water in the lake has risen. And it's rising in the well, too."

"The water level in the lake has fallen. It's also fallen in the well."

A sounding-lead was lowered into the lake, and another into a well in the neighbouring Zaal estate. Every day Reinvald and the teacher took down the readings.

What could there be in common between Lake Kaali and a neglected well? But there proved to be some connection between them because any change in the water level in the lake was at once reflected by the water level in the well. That killed yet another tale: it was established that the level of the lake was governed not by an outlet to the sea but by subsoil waters.

Reinvald's men now used spades and picks instead of a bore. The geologist wanted to know what rocks the lake's shore was made of and what the state of these rocks was. It was hard work. The cuts ran from the top of the bank to the water's edge. Reinvald knew what the upper strata consisted of. Beneath the clayey alluvium and the rocks there were layers of upturned dolomite and limestone. It was as though the giant Suur Töll had in a fit of rage torn chunks of rock out of the ground and scattered them.

"This is the work of a Goliath," old Lillo said, examining the chunks.

But beneath the upper strata Reinvald was astonished to see crushed rock. Some of them were so small that they were more like flour. He scooped up some of these yellow fragments and found that he could rub them into powder with his hands. It seemed that having grown tired of

working with his hands Suur Tõll had decided to grind, trample the stone with his feet. Reinvald could not tell how thick this layer of stone flour was.

He ordered his men to sink a well into the powdered rock. "I thought it necessary," he wrote in his diary, "to find out the vertical and horizontal arrangement of this flour stratum."

It turned out that this flour lay round the crater, forming a belt two and a quarter metres wide and about six metres deep. The subsoil waters prevented the team from learning what lay beneath it.

Reinvald decided to sink a well in the Zaal estate. Even the devoted Lillo grumbled when he received the order to begin digging: "What's the point of boring here? We'll only blunt the bore for nothing. There's no hollow around here."

But he soon saw what Reinvald was driving at. The bore moved as usual. There were no upturned layers and no stone flour, nothing but undisturbed strata of dolomite and limestone. The stratification was orderly.

"Suur Tõll was formidable, but he didn't get around everywhere," Lillo said.

Reinvald wrote in his diary: "These investigations brought us round to the conclusion that this flour does not form a regular layer between other rocks throughout the island but only lies around the crater."

It grew colder, particularly at night. The men began to talk more and more often of returning home. Reinvald, too, was feeling homesick. But he could not tear himself away from Lake Kaali. He was completely under the spell of that exquisite, lofty and unselfish feeling called scientific interest.

In later years he would be gripped by this feeling whenever he would return to a study of Lake Kaali. It would serve as the source of the few joys that fell to his lot.

Reinvald ordered his men to sink exploration wells in crater No. 1, a small hollow 32 metres in diameter.

But before the men could start digging the wells they had to root out the trees growing thickly in the "dry lake".

Reinvald found that the rock pattern in crater No. 1 was the same as in Kaalijarv. The top layers consisted of upturned rock—Reinvald called them the upthrust zone—and beneath them was a layer of flour, the zone of destruction. The only difference was that they were not as wide and thick as around Kaalijarv, as though it was the handiwork not of Suur Tõll but of his younger brother.

Because the layer was thinner Lillo and his team quickly reached the next zone. It proved to consist of undisturbed horizontal layers of rock, and Reinvald called it the undisturbed zone.

The excavations in crater No. 1 and in another hollow in the vicinity, in which there also were an upthrust zone, a zone of destruction and an undisturbed zone, allowed Reinvald to make the following short entry: "The identical origin of the small craters and of Lake Kaali has been confirmed."

There were other craters, and Reinvald would have liked to sink wells in each of them and to continue his investigations of Kaalijarv itself. But he could not delay his departure any longer. The time limit fixed by Kuusalu had expired long ago. Autumn was coming into its own. It rained incessantly. Reinvald ordered his men to start packing.

IMPASSE

After his return from Saaremaa he began to analyse the data collected by him and ponder over what he had seen. He realised that something phenomenal and unusual had happened on the island. The riddle gave him no peace.

He paged his way through books, pamphlets, old newspapers and magazines. On each page he met his predecessors. Edward Eichwald, Friedrich Schmidt and Vangenheim, the noted scientists whose works he had studied at the institute, now became living people for him.

The first mention in scientific literature of the problem of Lake Kaali was, Reinvald found, in a magazine dated 1827. In it Doctor Lutze, an expert on Saaremaa Island, described Kaalijarv in detail but was unable to explain its origin.

Reinvald read through a thick volume by the German scientist Vangenheim, who visited Lake Kaali in the mid-nineteenth century. What was his opinion about the lake? How did he explain its origin?

Vangenheim believed that the lake was of volcanic origin, that there was an eruption of gas at some time in the remote past. Water filled the crater of the volcano, which has been dormant ever since. But very long ago it had been active.

Vangenheim, Reinvald was positive, did not have in mind such fire-breathing mountains as Klyuchevskaya or Etna. While travelling along the lower reaches of the Rhine, he had observed volcanoes which, compared with Klyuchevskaya or Vesuvius, seemed undeveloped pygmies. When such volcanoes come to life, white-hot gases gush out of the ground and an explosion throws rocks high into the air. The eruption ends there. The volcano consists of a vent formed by the explosion below the level of the torn surface. Some vents are surrounded by a low bank. Filling with water these vents become lakes. On the Rhine they are called maars or crater lakes.

Vangenheim regarded Kaalijarv as such a crater lake.

What objection could Reinvald raise to this theory? All of Vangenheim's arguments seemed to be substantiated and well thought out. Besides, it was not easy to bring oneself to argue with a recognised authority.

Reinvald turned to the work of another scientist, Edward Eichwald, a Russian, who had his own theory about the origin of Lake Kaali. He maintained that the lake was man-made, that it was all that remained of a castle on a hill built by peasants.

The ruins of such castles, built in the Middle Ages against invasion, are to be found on Saaremaa to this day. They were erected by the Saaremaa peasants in swamps and surrounded by deep moats and a high embankment of stone and earth. The hills on which these fortresses stood were man-built and have become known as peasant hills. Eichwald held that Lake Kaali marked the site of a castle where the people of Saaremaa withstood long sieges and organised daring sallies against the enemy.

Once more Reinvald refrained from starting an argument. He took down a book by Friedrich Schmidt, founder of Estonian geology, honorary member of numerous scientific societies and the leading authority on Baltic geology and paleontology. His theory was that Kaalijarv owes its existence to a karst cave-in of the ground.

Karst is a limestone plateau on the Adriatic in the vicinity of Trieste. Its sole feature is that it is dotted with hollows, sinks and lakes. How did they originate? An interesting picture unfolded before the investigators who asked themselves that question. An unknown builder had dug caverns, wells and horizontal passages, a veritable labyrinth in which one could easily get lost.

That unknown builder was water. Penetrating deep into the Earth's crust through rifts, it destroys the rocks in its path. But not all of them dissolve with equal speed and facility. Limestone, dolomite, gypsum, marble and rock salt yield to the tireless persistence of water much more quickly than other rocks.

Underground rivers and streams flow for centuries, slowly, drop by drop, eating away rock. Tiny crevices grow and widen to become huge cavities and wash-outs

In the end they grow so large that the surface caves in, giving rise to sinks, hollows and depressions

There are many of these hollows in the world and they have been named karsts after the place where they were first studied. Some of them became filled with water so that it is hard to distinguish them from ordinary lakes.

Professor Schmidt believed that Lake Kaali was a karst hollow. Like the others, this theory was well-grounded, for Saaremaa Island was composed of limestone and dolomite. That meant there could be underground voids, and where there were voids there were sure to be vents and karst lakes.

These purely hypothetical propositions did not satisfy Reinvald. He wanted facts and to see things for himself. He took the step that the quiet geologist had hesitated to take. He began an argument with his famous predecessors, at first timidly and irresolutely, then with growing determination.

The boring had shown that there was no salt on Saaremaa. There was nothing easier than to disprove Kuusalu's salt theory, but it was the most dangerous thing Reinvald could do, for Kuusalu became his lifelong enemy.

It was not easy to demolish Eichwald's hypothesis. However, Reinvald produced facts that vanquished it. He went to Saaremaa and examined the peasant hills, whose origin had been established beyond doubt.

The walls of these fortresses were built of stone cemented with earth They did not consist of chaotically scattered boulders. Inside each fortress there was a deep well that bore no resemblance whatever to a lake. Kaalijarv was definitely not anywhere close to a fortress. It had never been a refuge of the fierce islanders.

Reinvald rejected the theories of his predecessors but could offer nothing to replace them.

What had wrenched the boulders out of the ground and scattered them? Time had not erased the action of high temperatures on these rocks. What had caused these temperatures? The limestone and dolomite were crushed. What had ground them? Beneath the powder lay undisturbed strata of rock. How did they escape destruction?

Day after day Reinvald grappled with these problems.

Late every night only one light burned in the suburb of Nõmme. It came from Reinvald's study, falling on the road and the sleepy, resinous pines, and disappearing only with the approach of dawn.

Analysing and comparing facts, Reinvald came to the conclusion that Lake Kaali and the small craters around it were formed by an explosion.

"Everything," he wrote, "points to the fact that some solid body flying at a great speed had hit the ground. What was this body? It could only have been a meteorite." At that time it was a new, daring and unexpected conclusion.

Meteorites, stony or metallic bodies formed somewhere in interplanetary space, fall on the Earth quite frequently. However, this concerns only small meteorities. Large bodies reach our planet much less frequently.

But could meteorites have left such deep and long-unhealing scars? An enormous meteorite called Goba lies tranquilly in South-West Africa. No deep craters or traces of an explosion are to be seen around it. Why then did the Saaremaa meteorite leave such a deep imprint on the ground?

Meteoritics was unable to answer these questions. It was only getting ready for coming discoveries, accumulating facts and conducting observations. Reinvald was among the first to speak of meteoritic explosions. Two other scientists were at that time also working on the same

problem. They were Leonid Kulik of the Soviet Union and Daniel M. Barringer of the U.S A.

At the close of the nineteenth century Barringer discovered a huge crater of 1,200 metres in diameter in the Arizona desert. Upturned rock fragments were scattered along its upper edge, while in the crater itself there were lumps of sandstone that bore traces of having been a mass of molten rock. The origin of this crater was the subject of a scientific debate that lasted for many years. Barringer was the first to suggest its meteorite origin. For a long time nobody believed him. But he dispelled all doubts when he found fragments of meteoritic iron around the crater.

Leonid Kulik doggedly searched the Siberian taiga for the Tungus meteorite that fell in 1908. He found the approximate place where the fiery stone landed, discovering a singed forest and numerous holes and craters.

Reinvald read everything he could lay his hands on about the discoveries of Kulik and Barringer. Soon the craters found by these scientists became as familiar to him as if he had investigated them himself.

The more he learned about the Arizona crater the firmer became his belief that his hypothesis was correct, that the craters in the Arizona desert and on Saaremaa Island were formed by one and the same mighty force.

Indeed, along the edges of the Arizona crater Barringer found dislodged layers of rock. The pattern was repeated around Lake Kaali.

In one of Barringer's articles Reinvald found the words "star dust", which were applied to the loose sediments of quartz and sandstone beneath the disturbed layers. This was reminiscent of the stone flour, the dolomite and limestone powder that Reinvald found around Kaalijarv.

Beneath this powder Reinvald discovered undisturbed horizontal layers of dolomite and limestone. The same picture was revealed to Barringer when his bore hit into the bed of the Arizona crater.

In the crater in Arizona the American scientist found lumps of once-molten sandstone. Reinvald had held in his own hands fragments of dolomite that had traces of contact with fire. The size of the craters, too, told an eloquent story. Reinvald made the following entry in his diary:

	Arizona crater	Kaalijarv
Depth	150-165 m	13-16 m
Wall height	50-60 m	6-7 m
Diameter	1,275 m	110 m

Kaalijarv resembled the Arizona crater as a son resembles his father. It was 10-11 times smaller.

In the Arizona desert there is one crater. On Saaremaa there are seven—Kaalijarv and some shallow hollows to the south-east of it.

This, too, had an explanation. Before reaching the Earth meteorites frequently break into pieces, showering the Earth with a hail of stones or iron. That, evidently, was what happened on Saaremaa. A giant meteorite disintegrated and each of its pieces hit the ground with an explosion as though it were a shell. The craters were made by these explosions.

Reinvald was now quite certain of the craters' meteorite origin. To settle this problem he needed meteorite fragments. But the meteorite fell many centuries ago and, as distinct from the Arizona meteorite which landed in a desert, it hit a densely populated island. These fragments were as difficult to find as a needle in a haystack.

STARS FROM THE SKY

When Reinvald went to make his report to Kuusalu he expected anything—indignation, arguments, distrust, doubts—but indifference.

Yet Kuusalu listened with complete indifference.

"Fiddle-faddle," he said interrupting Reinvald's carefully prepared report. "You are a first-class geologist, Reinvald. But you don't have the clay of a scientist. To support your theory you must show at least one fragment, a tiny star from the sky. That's the long and short of it."

Dismissing the subject, he spoke of the new projects that he intended assigning to Reinvald.

But as soon as the door closed behind Reinvald, he dropped his mask of indifference. He leaped out of the armchair and began pacing the big office.

He was disappointed to hear from Reinvald that there was no salt on Saaremaa. His hypothesis crumbled. It meant he could not make any claim to fame. But his disappointment soon passed.

In all probability the meteorite theory was just a piece of balderdash. Reinvald would not get the money or opportunity to continue his investigations. Assignments to the remotest parts of the country were what awaited him. Kuusalu would see to that.

Reinvald sought the support of other important officials. But he was met with the same indifference. Nobody showed any interest in his discovery. He soon realised that he would not be given funds for his investigation of Kaalijarv. What was there to be done? His wisest course was to give up these investigations and forget about the lake. But that was exactly what he could not do. He already saw visions of himself, old Lillo and the teacher Folma digging in the crater, of their spades hitting something hard, a meteorite fragment, and of him writing of his discovery to Kulik.

But bitter reality brought him down to earth. He paced his study, pondering how to find time for work in Kaalijarv and money to pay for it. He could use his annual holiday and also his Sundays. What about funds? He

had some savings for a rainy day But his wife had had to scrimp and save to put away that money and he hesitated to ask her for it. Besides, there wasn't enough to pay for an expedition.

For the first time in his life he did not share his thoughts with his wife. She could see he was worried but could not put her finger on the reason.

One day a letter addressed to Reinvald came from Tartu University. Curiosity got the better of Lydia and she opened the envelope. The well-known Estonian scientist Luha, to whom Reinvald had sent his manuscript, warmly congratulated him on his discovery and wholeheartedly supported his meteorite theory. He could not help Reinvald organise an expedition to Saaremaa, but he was happy to inform him that his manuscript would be published. It would be printed with a foreword by Luha. Lydia carefully folded the letter and that same evening brought the subject up with her husband.

"Not every geologist has the luck to solve a long-standing problem. Why are you shilly-shallying? Take all the money we have and begin work. And promise you'll never hide anything from me again."

"I promise," Reinvald said happily. "I don't have the right any longer. You are a partner in the firm of Reinvald and Family."

AN EXTRAORDINARY ARCHIVE

"I can't see why that hole's giving you no peace," Lillo said with a shrug. "It's Sunday today and everybody's already been to church and is sitting down to dinner. You're the only one working."

Reinvald was standing in a deep crater and digging with a spade. Had it not been for Lillo he would have gone on working till nightfall. It had cost a great effort

to get to Kaalijarv and he had much too little time. He could not afford to waste a single hour.

He had examined Lake Kaali two years before, during his first visit to Saaremaa. Now he selected one of the neighbouring craters. It was much smaller than Kaalijarv, dry and required much less digging. He called it crater No. 4. But as far as Lillo was concerned it was only a hole. A fresh clod fell on Lillo's Sunday shoes. He took off his jacket and waistcoat, which he wore only on holidays, carefully wrapped his shoes in his scarf and joined Reinvald in the hole.

It was about 20 metres wide. The trees had been uprooted together with the thickly growing nut bushes and oak and ash saplings. When finally the rocks were cleared away Reinvald saw that like the lake crater No. 4 was filled with dolomite fragments and glacial debris. He began to dig through this mass to the bottom. The spades struck rocks, some of which were so big that the men had to strain to get them loose.

... When a historian has to restore a page of the past he goes to the archives, where he digs up chronicles, manuscripts and the accounts of eye-witnesses.

The event Reinvald was studying had taken place long ago. But it was not mentioned in any chronicle or reminiscences. Nonetheless he had an archive to fall back on. It was the Earth itself. It alone "remembered" that awe-inspiring catastrophe, retained traces of it and could tell its story.

To the geologist each layer of soil is like the page of a book. It tells him even about torrential rains that fell millions of years ago. The traces made by these downpours hardened in the soft alluvium, turning into fossilised imprints.

Reinvald refused to believe that the soil would not yield up at least one meteorite fragment.

In 1927 he had read the first pages of this "archive".

The dolomite zone of destruction told him that a catastrophe had taken place. And now, digging through the layers in crater No. 4 he reread these interesting pages.

He dug through the metre-wide strata of dolomite and the fine, sticky stone flour, but found no trace of non-terrestrial iron.

He panned the sand and examined it through a magnifying glass, but it contained nothing except dolomite and fragments of glacial drift.

Reinvald and Lillo continued digging. The hole grew wider and deeper. In each clod of earth Reinvald's inflamed eyes searched for the glint of iron from some other world. Lillo fancied he saw the reddish, intoxicating gloss of gold.

STEPS INTO THE GROUND

Several more days passed. The hole was almost four metres deep. They had reached solid rock. Reinvald decided to stop digging and clear the bottom of the hole.

Lillo's men began to throw rock fragments out of the hole, clearing the floor, which was even and smooth.

They worked silently. Reinvald noticed a cavity in the smooth floor, which gave the impression that somebody had been at work digging in it. Telling the men to stop working he removed the loose soil in the cavity. An hour later he found a vent before him.

He measured it. It was 40 centimetres deep and five and a half metres wide.

"This is where we must continue our search. If we don't find a meteorite fragment here. . . ."

Reinvald began clearing the floor in the vent. Soon he threw away his spade and began feeling the floor with his hands.

There was nothing. He had been almost sure that he would find a fragment that he could take to Tuuling. But

there was nothing. He returned to the farmstead empty-handed.

Had all this time been wasted? Upon his return to Tallinn would he have to admit defeat? When he had asked for a holiday, Kuusalu had said mockingly, guessing where he was going:

"Shall I send a train for you to Saaremaa? Do you imagine you can bring your meteorite in your pocket?"

These mocking words still rang in his ears. "What am I going to bring back. A trainload of sand? Or my helplessness?"

... In the morning they returned to the crater.

Lillo watched Reinvald feeling the sand and knocking on the wall. The old man interpreted things in his own way: "He's probably looking for an underground passage. Perhaps somebody's hidden treasure here?"

Standing in the vent, Reinvald and Lillo cleared it of rock fragments. To his astonishment when they reached the floor, Reinvald saw another cavity, another step. It seemed to invite him to step down into a new, smaller vent. He bent down to examine it, carefully clearing it with his hands and a wooden spade. The third vent, like the second, was shallow, not more than 50 centimetres deep. It was three-edged with rounded ribs as though it had been pressed into the sand. The edges were crushed and lamellar marl was compressed into the opening. Reinvald saw that along the edges of the vent the dolomite was lighter than elsewhere.

He carefully examined the vent, almost expecting to find another cavity, another dolomite step leading down to yet another vent. But there was no cavity in the floor. These stepped cavities leading nowhere are called blind openings by geologists. Reinvald called it a blind crater.

But what is a blind crater? How did it appear? Who made it? The answer suggested itself. Reinvald had found

the spot where the meteorite had hit the ground and exploded. This was manifested by the depressed layer of marl (the concavity could only have been caused by a powerful blow), the light colour of the dolomite imparted by the action of high temperatures, and the crushed rock surrounding the blind crater. The crater itself was made by the impact of a meteorite.

Reinvald could not restrain his joy:

"Folma! Lillo! Tuuling! Friends! I think we've found what we've been looking for."

The men ran to him. With Folma was a smartly dressed elderly man Reinvald had never seen before. He stretched his hand out to Reinvald and said in German:

"My name is Alfred Wegener. I've come to you for only two or three days. I hope you'll allow me to examine your crater."

Wegener. To scientists this name is associated with challenging hypotheses and breath-taking adventures, persevering quests and daring theories, in which scientific discovery is intertwined with legend and romance and it is difficult to draw the line between reality and fantasy.

At the turn of the century, in order to study the lower layers of the atmosphere Wegener risked being borne aloft by a freely sailing aerostat. He stayed in the air for the record time of 52 hours. When he was told that he had set a world record, he apologetically shrugged his shoulders:

"I hope the sportsman whose record I have broken will excuse me. Tell him I had no intention of competing with him. It was simply that I was unlucky and could not get the data I wanted quickly. I had to dangle in the sky much longer than I had planned. That's all there is to it."

Several years later a new hypothesis fascinated Wegener. He contended that at one time all the continents were

an unbroken mass which floated on the earth's basalt jacket in the same way as icebergs float in the polar seas. The initial land mass gradually broke up and formed the modern continents.

Wegener's theory was fiercely opposed. Arguments continue to rage around the Wegener theory to this day—some scientists flatly reject it, others accept it with reservations. Wegener countered every refutation by his opponents. In search of proof he set out on one dangerous expedition after another.

Meteorites were one of his fads. He fancied he saw their tracks not only on Earth but also on other planets. He declared that the enormous craters on the Moon were made by meteorites.

Incidentally, this hypothesis has the support of some scientists to this day. Some time ago the Soviet astronomer N. A. Kozyrev observed a volcanic eruption on the Moon, proving another hypothesis, namely, that the cirques and craters on the Moon were formed not by meteorite bombardment but by volcanic activity.

Hearing of Reinvald's work, Wegener went to Saaremaa to make a thorough-going examination of Lake Kaali and the craters around it. Reinvald did not interfere in his investigations, hurry him or ask questions. Wegener himself went to Reinvald.

"Congratulations," he said, embracing Reinvald. "I wholly subscribe to your hypothesis. There is not the slightest doubt that these are meteorite craters. Unfortunately I cannot stay here longer, but I shall come back next summer and act as your assistant."

A wave of joy swept over Reinvald. The great Wegener supported him. More than that, he wanted to help in the investigations. His, Reinvald's, days of isolation were over. He would work with a renowned scientist, with Alfred Wegener.

When Wegener departed, Reinvald resumed his study of the blind crater. He felt he had found the trail leading to his objective.

A specialist can tell how tall a man is by the imprint of his foot. In the same way Reinvald determined the size and weight of the meteorite. The blind crater was the imprint of its "foot". It was 50 centimetres wide. That should have been the diameter of the meteorite fragment that made crater No. 4. Its weight could be anything up to half a ton. But the fragment did not simply land on the Earth. It blew up, forming a crater many times larger than itself.

Reasoning in this way Reinvald determined the size of the fragments that formed the other craters. According to his computations, Lake Kaali was made by a meteorite of approximately three metres in diameter.

Judging by the power of the impact the cosmic body consisted of iron.

Reinvald closely studied the shape of the blind crater. It was elongated from east to west. That, evidently, was the direction in which the meteorite flew.

When did it arrive? In what century? In what millennium?

The answer was given by the Earth, in which numerous ancient "documents" survived.

Reinvald reviewed Saaremaa's geological history.

The last, fourth glaciation occurred many thousand years ago on the Scandinavian peninsula, whose southern tip was still a part of the continent. Tremendously thick, the glacier lay on that part of the Earth which is now Sweden, Norway and Finland. From there it came down and spread over Europe, including the patch of ground that much later was to become Saaremaa Island.

A cold and wet period set in. The animals accustomed to a warm climate, moved southwards. But the sea formed

a barrier in their path, trapping them. Some managed to reach a warmer climate, others perished and still others adapted themselves to the cold.

But about 30,000 years ago the glacier began to melt, to crawl back to its northern den. It retreated, leaving behind it lacerated shores, numerous fiords and bays. It left other traces—polished bones of animals, hills and cliffs with smooth cupola-shaped tops, and a countless number of rounded boulders.

In the Saaremaa craters Reinvald found only what got into them after the explosion—fragments of dolomite and glacial boulder deposits. That meant the meteorite fell after the glacier had retreated.

Reinvald knew that the glacier retreated from the territory of Sweden only 18,000 years ago, and from neighbouring Finland 10,000 years ago.

After the glacier disappeared its place was taken by the Littorina Sea, about 7,500 years ago. It occupied the area where the Estonian islands are now situated. Violent winds blew and storms raged. Some 5,000 years ago land joined battle against the sea and began to rise. The sea was forced to retreat. It grew smaller and narrower and became the Ancient Baltic, which occupied approximately the same area as the modern Baltic Sea. That was when Saaremaa Island appeared. The meteorite, therefore, fell after the island had risen out of the sea, not earlier than 5,000 years ago.

That sharply reduced the number of millenniums. But it did not make it any easier to establish the exact date. Reinvald perseveringly searched through the ancient "documents."

In the crater he found bits of charcoal. What if they had been the branches of graceful pines or shaggy firs? They were burnt and turned into charcoal before the explosion, by the streams of compressed air from the head

wave that reached the Earth before the meteorite. The forests on the island now consisted of similar pine and fir. The summers were cool and the winters mild. The same climate must have obtained when the meteorite fell. But a long span of time passed before a moderate climate allowing trees to grow established itself on Saaremaa following the retreat of the Littorina Sea.

Among the debris in the craters were shells of land molluscs. Some of these shells had been shattered by pieces of dolomite. That meant they got into the crater at the time of the explosion. Reinvald recognised the shells as belonging to garden snails, large numbers of which lived on the island about 3,000 or 4,000 years ago. That gave him a more exact data: the Saaremaa meteorite fell three or four thousand years ago.

The Sun shone peacefully on the sea, bathing the island in light. A red-hot flaming ball suddenly appeared in the sky. It fell with lightning speed and broke into pieces over the rocky island in the Baltic, striking the spot where Reinvald was now standing. There was a deafening explosion. Fragments of meteorite, lumps of dolomite and pieces of rock flew in all directions from the holes formed by the explosion. The subsoil waters turned into steam.

For a moment Reinvald thought he could feel the steam on his face and he instinctively covered his face with his hands.

At the time the meteorite fell there were mighty states in the world—Egypt and Hellas. Hammurabi had already recorded his laws in cuneiform on stone. Man was already writing treatises on the causes of heavenly phenomena and trying to measure the distance from the Earth to the Sun. The Greek bards were composing the *Iliad.*

"My meteorite must have had its own bard," Reinvald thought. "The ancients could not have failed to create a myth about such a remarkable phenomenon of Nature.

Legends and stories have been composed wherever meteorites fell."

But try as he would he could find no myth linked up with the appearance of the Saaremaa meteorite. He had to continue his investigations of crater No. 4 and find a fragment of the meteorite. But that could not be done without a boring derrick. Within three days a rough-hewn tripod stood over the crater.

Reinvald's holiday was nearing its end and he had to hurry. The bore sank ever deeper into the ground, and when it rose the men crowded round hoping to see a meteorite fragment. But each time they were disappointed.

... The storm broke out suddenly. It grew dark. Heavy clouds hung low in the sky. The sea roared angrily. A ferocious wind blew from the sea, whining in the crowns of the trees, beating up waves in the lake and bending the tall, thickly-growing grass. The birds hid in their nests. In the neighbouring field the rain and wind drove the mowers to the shelter of the haystacks. Only Reinvald and his team remained in the open.

Suddenly, above the shrieking of the wind, he heard Lillo's warning cry:

"Look out!"

The tripod groaned like the mast of a sailing ship during a storm. But he had no time to leap away. The tripod crashed to the ground and some heavy object knocked him off his feet.

...A heavy cart moved laboriously along the road to Kuressaare. Reinvald lay on the hay covered with a warm blanket. Lillo sat beside the driver. When the horse quickened its pace the old man pulled the reins, slowing it down.

Reinvald groaned weakly. During a moment when the pain abated he said to Lillo:

"We'll find it next time, we'll definitely find it. Next time Wegener will be with us."

DEATH OF A FRIEND

Reinvald's illness kept him bedridden for several months. During these months he thought over many things, analysed his hypothesis and once again came to the conclusion that it was correct. He was tortured by the fact that illness had struck him down when he had hit upon the track of the meteorite. Instead of lying in bed he should have been following up his discovery, searching, and organising a new expedition.

The doctor forbade even reading. His wife and older children took turns to read to him. He asked them to look carefully through all the newspapers for news of Kulik. One day, as his son Yura was reading the papers to him, he came across an item mentioning Wegener. Reinvald sat up.

"Read that again," he said to Yura. "No, give it to me, I'll read it myself."

The report was from Germany and it stated that the famous German scientist Alfred Wegener had disappeared somewhere in the ice wastes of Greenland.

Soon Reinvald learned details of his friend's death. Wegener had set up a station in the centre of the ice shield and called it Eismitte. His own headquarters were in Umanak Fiord on the western coast.

One day a message was received in Umanak. It stated: "The food supply at Eismitte is running out. Send help."

Wegener, his friend Dr. Leve, and fourteen Eskimos set out in response to this call for help. It was September. There was a piercing frost. A blizzard blew in their faces, blinding them and knocking them off their feet. Thirteen of the Eskimos turned back. Wegener pushed on. Only Dr. Leve and an Eskimo guide by the name of Rasmus followed him.

They suffered not only from the wind and the frost. They had to carry a load that had been distributed among

fifteen men. The three brave men were forced to leave most of the supplies behind.

The food that Wegener and his friends brought to Eismitte proved insufficient. The professor decided to go back to Umanak for more supplies.

They started out on November 1, on Wegener's fiftieth birthday. There were two of them. Leve could not accompany them because his feet were frostbitten. Nobody saw Wegener and his guide again.

This was a heavy blow for Reinvald. It meant he would have to carry on alone.

He continued planning a new expedition. Lydia sat at his bedside. "I have a dreamer for a husband," she thought as she listened to his plans. "A new expedition! Where are you going to get the money for it? You haven't paid off your debts for your last trip. Lillo hasn't received any payment at all."

Reinvald's illness put his family into financial difficulties. There was nobody from whom they could borrow even as little as a hundred kroners.

They could, of course, get a loan from the bank, and Reinvald would pay it back as soon as he returned to work. But someone had to sign the guarantee. Who would do it when Reinvald was not getting his salary for so many months? They had no rich friends.

ANXIETIES AND DISCOVERIES

The thirties were a period of anxiety for Estonia. The country simmered. President Päts could not make up his mind where to steer his tiny boat—to the German or the English shore. Which of the dreadnoughts was more powerful? Whose guns were more dependable? The president had not the least intention of steering an independent course. In the beginning it seemed to him that Britain

was stronger and he sailed in her wake, then he switched to the side of German nazism.

The nazi flood swept over Estonia. Päts clinked glasses with Hitler's generals and cried "heil" to the Fuhrer. The chief of the German General Staff reviewed the local nazis. The president boasted to him: "My Estonia is organised after the model and along the lines of great Germany."

Even the black tulips for his park came from Germany, and he named the alpine garden at his residence in Kadriorg a "corner of Germany".

But there was another side to the picture, which Päts preferred not to speak about officially. Secret printshops turned out leaflets at night, and Communists gathered in outlying streets and out-of-the-way places. Strikes broke out, and the workers had bitter things to say about the president.

Reinvald tried to turn a deaf ear to the news from Kadriorg. He wanted to preserve a corner of his own, independent Estonia in his home. But he knew nothing of the activities of the Communists. In those years he kept the door of his study tightly shut.

One thing alone made him open it wide. It was the news of further riddles, discoveries and quests for meteorites.

In 1931 it was reported from faraway Australia that thirteen bowl-shaped holes were discovered in the Hanbury Desert. Reinvald eagerly read this news. The next report stated that upturned layers of rock, stone flour and, lastly, meteorite fragments were found in that desert. This confirmed the fact that a huge meteorite disintegrated over the Australian desert many hundreds of years ago.

In 1932 the newspapers carried the important news that investigators working in the Rub' al Khali Desert in South Arabia came across two craters. The pattern was the same: upturned layers of rock with stone flour beneath them.

In 1933 news of a meteorite came from the Gran Chaco Desert in Argentina. "It's amazing how shy these visitors from outer space are," Reinvald thought. "They land in deserts, far from human habitation. Mine was the only audacious one, landing in the heart of Europe."

But soon it was reported from Haviland, Kansas, U.S.A., that a meteorite had been found near a farm, which became known as the Meteorite Farm. The crater was discovered only several decades later. "It's the opposite in my case," Reinvald said. "Everybody can see the craters, while the meteorite fragments...."

Reinvald attentively followed the discoveries of his counterparts in various parts of the world, compared their findings and pondered over their significance. He was particularly interested in the group of craters in the Hanbury Desert.

It was the first group whose meteorite origin was proved. Comparing the Hanbury and Saaremaa craters he found a striking resemblance between them. They were dish-shaped. Each group had an oval crater: No. 2 on Saaremaa and the Grand Crater in the Hanbury Desert. This oval shape was due to the fact that two fragments landed side by side. Along the edges of the Hanbury and Saaremaa craters the rock strata were upturned and had stone flour beneath them. The burnt sandstone in Hanbury and the singed dolomite in Kaalijarv indicated that the temperature had been extremely high. There was a similarity even in the size of the craters.

Thus, without having any direct evidence of Kaalijarv's meteorite origin, Reinvald proved that his hypothesis was correct.

He paid no attention to what was happening in the country, believing that it would in no way concern him in the quiet of his study in Nõmme or at the bottom of the Saaremaa craters.

But he was deeply mistaken.

He decided to spend his next short leave on Saaremaa. This time he was luckier, for he was accompanied by his friend Professor Luha.

They arrived in Kuressaare late in the evening and wanted to go on to Kaalijarv at once. Darkness had fallen and there was a tempestuous wind such as could blow only on Saaremaa. Friends (all the inhabitants of Saaremaa regarded themselves as Reinvald's friends) persuaded the scientists to wait until morning. They spent the night in a log hotel huddling at the side of the forbidding 700-year-old episcopal castle.

In the tiny café they were served with sweet beer (a specialty on Saaremaa), smoked eels and sweet buns baked according to a special recipe.

Early in the morning they resumed their journey. When they were in sight of Kaalijarv they saw Otto Tuuling hurrying across a field to meet them.

"We've had some strangers here. Three men. They inspected the craters," he informed the scientists.

"Who were they? Were are they now?" Reinvald asked.

"They packed yesterday and left."

"Pity. I should have liked to have seen them and heard what they had to say about Kaalijarv," Reinvald said.

"Forget it," Luha said. "Lead the way and show me your treasure."

Reinvald gave Tuuling his things and for a fleeting moment thought which of the craters he ought to show Luha first. He decided on crater No. 4 because it was unique for its blind vent.

On the way he again described crater No. 4 for Luha's benefit. To him it was almost as though it were alive, with its own personality.

"You'll see it all for yourself."

But what was this? Pushing aside the shrubs surround-

ing the crater Reinvald saw that it had been mutilated and filled with rubbish. Distraught with grief, he began clearing the rubbish with his hands. But the floor had been damaged. The blind vent had lost its former appearance. The upper edge of the crater had also been harmed. Its soft singed floor had been disfigured.

Reinvald sank on the grass. His enemies were more brutal than he could even imagine. There was a long silence. Finally Reinvald got up and brought some boards. Throwing them into the crater he covered them with large stones and earth in the hope of preserving what had not been damaged.

They went to Tuuling's farm in silence. Where else on earth could a blind vent be found? It was cruel that he had not had time to show it to the world. Who had perpetrated this piece of barbarism?

FORGERY

Reinvald's enemies continued plotting against him.

One day when he and Luha were in his study, somebody knocked loudly on the front door. A man wearing a black oilskin coat with a hood and high rubber boots came into the house.

"I want to see Mr. Reinvald. I have urgent business," he said.

"I am Reinvald."

The fisherman drew from his bag a stone with a hard crust of iron oxide. It was rounded on one of its sides.

Reinvald and Luha bent over the stone, turning it in their hands and estimating its weight. Finally, Reinvald said in a voice filled with excitement:

"It looks like a meteorite fragment."

"What do you mean it looks like? You're being much too cautious, Ivan," Luha exclaimed. "It's a real meteorite. I know what I'm talking about."

True enough, the iron had every appearance of being a meteorite fragment. This was success!

"Where did you get it?" Reinvald asked the fisherman.

"From the village schoolteacher in Koljala," the man replied. "And here's a letter from him."

In the letter the teacher informed Reinvald that he was sending a stone which he thought was a meteorite fragment. It was found by his pupils when they began digging holes for a new fence round the school.

While accepting his friends' congratulations Reinvald took the stone to his laboratory, where it was subjected to a careful chemical analysis. It was the only way its meteorite origin could be proved beyond doubt. A nickel content of four, five or more per cent would show that it came from outer space, because the nickel content of terrestrial iron does not exceed three per cent.

The analysis, however, yielded a result that came as a shock to everybody. There was no nickel in the stone.

Reinvald was bewildered. He could not understand it. Who had planted it on him? Why?

In his diary he wrote: "It's a mystery to me how this piece of iron got to Saaremaa and how its special form and appearance are to be explained."

The news that Reinvald's meteorite proved to be an ordinary rusty piece of iron leaked out of the Mining Department's Laboratory and spread in Tallinn with the speed of lightning.

Some scientists in Estonia and abroad were sincerely convinced that Reinvald was making a mistake. They did not believe that the impact of a meteorite could cause an explosion.

Then there was that ill-starred stone from Koljala. It was a potent weapon in the hands of the adversaries of the meteorite hypothesis.

"Father, the postman's brought a parcel for you," Natasha said, running to meet Reinvald on the porch.

On the round table in the dining-room was a small box with numerous labels. The children stood round the table, clamouring to know what was in the parcel. But Lydia told them not to open it.

Reinvald picked the box up. It was not heavy. The address of the sender was: Haviland. Nininger.

Reinvald felt his heart pounding.

He had become a noted authority on meteorites, but he had never seen a meteorite crater except Kaalijarv and had not examined a single meteorite fragment. There were no meteorite fragments in Estonia, and he could not afford to go abroad. All his money was being spent on his investigations on Saaremaa.

Although he was not recognised in his own country he was known to scientists the world over. They studied his writings and followed his investigations.

Other parcels arrived. Scientists in different countries sent Reinvald bits of the meteorites found by them.

He now had the opportunity of carefully examining meteorite fragments from the Arizona crater. One of the parcels contained a fragment found near a crater in Texas. Meteorite fragments were sent to him from distant Indochina.

Today the parcel was from Nininger, who investigated the Haviland crater. The fragment was from the Meteorite Farm.

It gave Reinvald renewed strength. "You'll get nowhere if you lose heart," he scolded himself. "You must expect your hypothesis to meet with opposition. You have more enemies than friends, but they're real friends."

He was right.

Luha alone was worth his weight in gold.

Then there was Kulik. Reinvald hesitated to write a letter to Russia, knowing what a risk that was. But though the two men never met they shared the same views.

Kulik began his study of meteorites in 1918. He regarded every success of meteoritics as his own, and took every failure close to heart. When Reinvald began to be attacked, Kulik warmly supported him, publishing an article in a magazine and speaking over the radio.

One day in 1936 Professor Luha telephoned to Nõmme.

"Doctor Clyde Fisher has approached me. He is the director of the Hyde Park Planetarium. He wants to look over your craters. I've asked him to contact you."

Reinvald knew of Fisher, having seen him many times on photographs near a huge 34-ton meteorite found by Robert Peary in Greenland and taken to a New York museum.

"I have heard of your work, but I am not taking sides until I have seen your craters," Fisher frankly warned Reinvald. "I like to see everything for myself."

On the next day Fisher went to Saaremaa, spending several days there examining and looking around the craters.

"This is the work of a meteorite," the American scientist said to Reinvald who joined him on the island.

MEETING WITH A STONE

Reinvald went to Saaremaa once more in the summer of 1937.

Ten years had passed since he had first begun his investigations of Lake Kaali.

On Saaremaa he again examined the craters. He looked calm, but his mind was in a ferment.

The excavations had entered their eleventh year. If he did not find anything in this latest attempt, Kuusalu and his friends would probably get the government to forbid any further work on the island on the pretext that he was

"spoiling the loveliest spot in the country". Moreover, if he returned empty-handed he would lose what little support was left to him.

That year he hired five workers and bought a bore. Lydia sacrificed the last of her savings. If he failed to find the meteorite, he would not have the means for organising another expedition.

As he wandered about the environs of Lake Kaali Reinvald reviewed his theory. The craters were formed by an explosion that took place when a part of the meteorite, which disintegrated in the air, violently struck the Earth. The explosion threw rocks out of the craters and, together with them, fragments of the meteorite. Most of these fragments should have landed near the craters. In Hanbury and Arizona fragments were found near the craters, where they lay on the surface of the ground and were easily detectable. Reinvald had searched everywhere but had failed to find anything either near Kaalijarv or around the adjacent craters. Ten years spent in the search had yielded nothing. The explanation was that the land had been cultivated for centuries. The peasants had cleared the fields of rock debris, and, together with it, of the precious meteorite pieces.

His only hope was that some of the fragments had fallen back into the craters. Everything that had landed in the craters after the explosion lay undisturbed for many centuries. He had to study the contents carefully.

But what crater should he begin with? He chose No. 2.

The thickly-growing nut-trees around this small crater formed an island in the sea of peasant fields.

Ignoring the drizzle, Lillo, Tuuling and the other men began to dig. Below the thin layer of black soil lay an undisturbed mixed stratum of dolomite and glacial drift. The large lumps of dolomite crumbled when they were struck with a spade. This debris had been thrown into the air by the explosion and then fallen back into the crater.

They worked as long as there was light. A mound of earth soon rose near the crater. Reinvald passed all this earth through a sieve, praying for at least one tiny meteorite fragment. The work made him forget Kuusalu, the intrigues of his adversaries and his financial difficulties. Petty worries drifted out of his mind, as he gave himself up completely to his work, doing it scrupulously and meticulously as only a scientist can.

Days and weeks passed. The upper layers filling the crater had been dug up and carefully sifted. But there was nothing in them. Lillo swore under his breath. Reinvald maintained an obstinate silence.

The mount of freshly-dug earth grew into a hill. All of Reinvald's hopes were pinned on that hill. He kept taking handfuls of earth and staring at it.

Suddenly he saw a small crooked stone thickly coated with rust. It lay in the palm of his hand. His heart missed a beat. He felt his legs grow weak and he sat down on a boulder. He knew that external appearances did not give him the right to assert that this rusty piece of iron was a meteorite fragment. On the other hand, it was an exact replica of the pieces of meteorite iron that were found in Arizona, Australia and Arabia.

He wanted to hurry to Kuressaare, take a ship or a bus, or if neither the one nor the other was available, hire a fishing boat and sail to Tallinn in order to examine his find there. But he fought down this desire. The fresh earth lay before him as though it were an unexplored country. He had only taken his first step into that country and had found only one fragment. There must be others. Time was precious. Lillo had prepared a whole mountain for him.

But where was his kind, grumpy friend? Reinvald went up to Lillo and stretched out his arms, wanting to embrace him. But the old man turned away. Reinvald's jubilation spelt disappointment for him.

"He's pleased that he's found what he's been looking for," Lillo said to himself, wrinkling his tow-coloured eyebrows. "But it's the end of my dreams."

Lillo realised that the fond hope he had cherished of finding treasure had vanished into thin air. And he strode away from the craters.

LILLO'S FIND

Next morning after hiding the fragment, Reinvald resumed his sifting of the soil at crater No. 2. Soon he found other fragments. Eighty cubic metres of earth had been dug out of crater No. 2 and in it he found 28 fragments weighing from 0.1 to 24 grams each. Their total weight added up to 102.4 grams.

After finishing his investigations of crater No. 2 he went over to No. 5, which was the smallest of the craters on the island. A few days were spent clearing it of stones, trees and shrubs. Then the digging began. Once more they toiled from sunrise to sunset, once more a mound of earth appeared near the crater, and once more the strain told on Reinvald's eyes and made his head swim.

Everybody was there except Lillo. He had been keeping away from the craters since the first fragment was found. Reinvald missed the old man's skilful assistance, his practised eye and even his grumpiness. He went to the neighbouring farmsteads, but nobody could tell him where the old man was.

One day while Reinvald was sifting the earth the men were throwing out of the crater, he noticed some black soil mixed with the brown debris. He jumped down into the crater and to his surprise found three bore pits in it. The first and second were not deep, but the third passed through the entire layer of debris and reached the dolomite floor.

Bore pits in a crater! It meant somebody had been there before him. An examination of the pits showed Reinvald that they had been dug long ago. When? He asked the local inhabitants. But even old-timers could not remember anybody digging in crater No. 5. They were ancient pits. "Perhaps they were dug by people 3,500 years ago when the meteorite fell. Perhaps they too were interested in the craters and, overcoming their fear, had decided to dig up one of them."

But these were only conjectures. Was there any way of learning exactly when these pits were dug? That was important because it would help to specify the date when the meteorite fell.

That day Reinvald could not find the answers to his questions, and when he returned home he saw a light in his window. He quickened his pace and, entering the room, saw Lillo sitting at his table.

"Lillo?" Reinvald exclaimed. "Where have you been?"

"On business," the old man growled and turned away.

He fingered a piece of metal, paying no attention to Reinvald.

"To hell with all those meteorites and all your stellar mechanism," he said suddenly. "I've found something that beats all your meteorites."

He gave Reinvald a thin metal plate with sharp ends and a simple ornament along the edges. It was covered with a green mould.

"Gold?" Lillo's eyes shone with hope.

Reinvald turned the plate in his hands.

"This is not gold."

The old man had not expected this answer and for a moment was speechless.

"What about the green mould?" he mumbled with difficulty.

"You get it on bronze as well," Reinvald replied calmly. "Tell me where you found it."

"Where your meteorite. . .."

A week before, when he had his fall-out with Reinvald, Lillo strode away unmindful of where he was going. His feet brought him to a small wayside eating-house. His bout of hard drinking lasted for several days, and when he finally sobered up he made up his mind to go to Reinvald.

"I'll make him pay what he owes me. Or I'll quit."

As soon as he said these words he bit his tongue hard It was as though he had recovered consciousness. "Where is he going to get the money from? He hasn't a cent to his name. Instead of helping I'll only be sinking him."

Barefoot and wearing only his trousers he rushed out of the eating-house and headed for the crater.

"He's probably worked himself into exhaustion." From a worker he met on the way he learned that Reinvald was now digging in crater No. 5.

But he did not find Reinvald at the crater.

The mound of fresh earth near the crater made Lillo burn with shame. "While I drank and slept they raised this hill. I'll make up for it."

He climbed into the hole and doggedly began to scratch at the earth in the ancient bore pit. Something pricked him. It felt like a nail. He withdrew his hand. Then he reached into the hole and pulled out a long, narrow metal plate. It was cold and rough with sand-grains sticking to it.

"I've found it!" he cried, the blood rushing to his head. "It's gold!" To make sure he ran to find Reinvald, from whom he had grown accustomed getting answers to all his questions. Reinvald was not at home and Lillo decided to wait for him. To while away the time he patiently cleaned the plate.

Reinvald listened with quickening excitement. Realising that Lillo had found the plate in crater No. 5, in the ancient bore pit, he leaped to his feet and began striding up and down the room. Then he again examined the plate.

In his hands he had a "document" that would help establish in what millennium people had dug in crater No. 5.

"This is a remarkable find, Lillo," he said. "This piece of metal is more precious than gold. It was made by man See this ornament along the sides? It was made by man who lived many hundreds of years ago and was interested in our meteorite. He dug the hole and accidentally dropped this plate. It's going to help us a lot."

... When the last of his money was spent and his holiday over, Reinvald returned to Tallinn. In his pocket lay a small bag that had been sewn by his daughter Elda. In it were 31 meteorite fragments and a bronze plate.

SIX PER CENT OF NICKEL

A thin, elderly man with a goatee met Reinvald and with a sideways look out of his blue eyes at the students rushing to and fro handed him a page from a small notebook. Reinvald read: "Ferrum—84.04%; nickel—6.45%."

"Congratulations," the man said quickly. "I've always believed you. Now everybody has to believe you. Only I wouldn't like anyone to know that I analysed it."

... After his return from Saaremaa Reinvald wanted the fragments to be analysed immediately. But this did not prove to be easy in Tallinn.

"We've already analysed your so-called meteorite," he was told at the Mining Department's laboratory. "We can't afford to waste time on a wild goose chase."

Professor Luha to whom Reinvald showed his fragments took him to this old man who was a scientific worker at the Tallinn Polytechnical Institute.

Now the analysis was ready. It confirmed that the fragments found by Reinvald were from an iron meteorite.

The old man took the geologist to his desk on which he saw one of his fragments. One of its sides was polished

and treated with acid. He picked it up to take a closer look. The polished surface bore fanciful linear patterns reminiscent of frost on window-panes.

"Widmanstaetten figures!" Reinvald exclaimed.

"Exactly," the old man said.

"But for some reason they are a little disarranged as though they have been disturbed," Reinvald said thoughtfully. "However, the important thing is that they exist."

The Widmanstaetten figures were further indisputable proof that Reinvald's fragments came from a meteorite.

Meteorite iron has a specific inner structure that differs from the structure of its terrestrial brother. It consists of nickel-poor strips running parallel to the edges of a regular octahedron. These strips are surrounded by nickel-rich iron. A beatutiful pattern of numerous regularly arranged criss-crossing strips appears when the surface of meteorite iron is treated with acid. This pattern is known as a Widmanstaetten figure. True, not all meteorite iron has this structure. On the other hand, no Widmanstaetten figure appears on terrestrial iron no matter how much it is polished and treated with acid.

Reinvald felt that one analysis was not enough. Soon some of the fragments from Saaremaa Island were sent to various parts of the world. A few went to Dr. Spencer, curator of minerals at the British Museum, London.

... The Mineralogical Society was holding a session in the large auditorium of Burlington House, Piccadilly, London. Dr. Spencer, the great authority on meteorites, asked for the floor. It was the same Dr. Spencer whose photograph can be seen in all textbooks on astronomy, the Dr. Spencer who found and investigated silica glass in the crater in Arabia. On the platform the scientist held up his hand. In his palm were small pieces of iron.

"Ladies and gentlemen, these pieces of meteorite iron are from Saaremaa Island," he said. "One more group of meteorite craters has been discovered on our planet."

"Who discovered them?" somebody in the audience asked.

"Ivan Reinvald," Dr. Spencer replied. "At his request I made a chemical analysis of these fragments. This iron contains from six to nine per cent of nickel."

Spencer, too, found Widmanstaetten figures on the polished and acid-treated surfaces of the fragments. These figures were absent only on one fragment, to which Reinvald had given the number 11. Spencer and Reinvald had, independently of each other, come to the conclusion that this was the result of the influence of high temperatures caused by the meteorite explosion. These temperatures destroyed the initial structure, while in the other fragments the Widmanstaetten figures were displaced.

Spencer made another important discovery. Further analyses showed that the fragments sent to him by Reinvald contained schreibersite and troilite, the former being a compound of iron with phosphorus and the latter of iron with sulphur. No such compounds exist on our planet. In extra-terrestrial conditions the chemical elements known to science form new combinations.

... Thus, in 1937, the secret of Saaremaa Island was finally solved and the world learned the name of the man who investigated Lake Kaali and the surrounding craters.

A CLOSED DOOR

One more of the Earth's mysteries was cleared up and Reinvald earned recognition among scientists all over the world.

From Berlin it was reported that Reinvald's work describing the discovery of meteorite fragments had been published. Professors from Berlin University were planning to visit Saaremaa and investigate the craters with a magnetometer.

An article signed by Clyde Fisher, an old friend of Reinvald's, appeared in the magazine *Sky*. "This is one of the few occasions in my life that I write with excitement and joy," Fisher declared. "Meteorite iron has been found in the Kaalijarv group of craters on Saaremaa Island in Estonia."

Leonid Kulik, who was then working on the elusive riddle of the Tungus meteorite, wrote in the magazine *Priroda*:

"I. A. Reinvald has proved that the Kaali craters were formed by meteorites. The scientists who worked there over the centuries failed to shed light on the origin of the lake. Reinvald solved the mystery."

This scientific opinion reached Kadriorg, the lovely palace built by Peter I in an oak park on the outskirts of Tallinn. It was now the residence of the republic's President Konstantin Päts.

The president "honoured" Reinvald with a visit to Lake Kaali, where he had his picture taken. Before leaving he said to Reinvald:

"Look up my brother Peter. He'll help you."

With his mind set on saving the craters from further destruction Reinvald went to Kadriorg on the very next day.

Konstantin Päts was spoken of as a foxy man, who had more brains than all his brothers put together. When he became president he compensated for his brothers' lack of brightness by giving them high positions.

He made Peter Päts director of the Institute for the Conservation of Nature with offices in one of this buildings at Kadriorg. This gave the younger Päts jurisdiction over parks, reservations and historical monuments. He was most of all concerned with primping them up to "satisfy the aesthetic requirements of the most important foreign visitors".

That was the man who received Reinvald.

Judging by the beaming smile, Päts was glad to see Reinvald. Without wasting time on preliminaries, Reinvald enumerated everything he wanted.

... The fragments that had been found were only the beginning. Funds were needed to allow the work to be continued.

... The craters were being destroyed. The peasants were using them as dumps for stones. They were becoming filled with sand, and rain was eroding them. The craters had to be fenced off and pavilions built over them.

... The meteorite craters could be turned into a museum.

"Just think, Saaremaa would be the only natural meteorite museum in the world," Reinvald said, warming up to the subject. "The island would attract tourists, scientists and people interested in astronomy. Besides the craters they would see meteorite fragments and photographs and drawings that would tell them about the meteorite craters in the world and how the Saaremaa meteorite was found."

Päts listened, nodding. He said he had to think it over and get another opinion, and asked Reinvald to call again.

That was the beginning of an almost daily visit to Kadriorg. But Päts was either away, ill, or busy.

Reinvald's letters, too, remained unanswered.

During one of his calls at the palace he came upon Peter Päts in the corridor. He thought he had Pats cornered at last. But Päts went past him and disappeared into his office.

Reinvald went to the door and knocked. Instead of an answer he heard the key turned. Disbelieving his ears he pushed the door but it did not open. He gave another push. But the door was locked.

After the appearance of long articles and photographs in the foreign press, the president felt he had to visit the craters. But that was as far as he went. He considered his mission completed and was no longer interested in

either the craters or in the scientist studying them. He felt there was no point sinking money into these holes

Standing before the closed door Reinvald finally realised that he would not get any help from the government.

TO THE FUTURE INVESTIGATOR

He took an unpaid holiday and went to Saaremaa with Lillo. He had only a few days at his disposal and he spent them around crater No. 2. The crater's dolomite floor had been cleared earlier by Lillo and his men. It bore all the traces of a meteorite impact. Filled with earth immediately after the explosion it had not suffered from wind and rain. Very little remained to be done to enable Reinvald to see and study what he had dreamed of seeing all these long years.

"Shall we begin digging?" Lillo asked. "There's not much left to do."

"No, we'll fill it. It'll mean more work, but there's nothing we can do. We have no choice," Reinvald replied, throwing the first clod into the crater and setting to work.

Lillo did not join him at once. He was puzzled. Reinvald had waited for ten years for a chance to look into the crater and now that he had it he was filling it with earth.

It had been a hard decision to make. Indeed, it would not take long to clear craters Nos. 2 and 5 completely. That would allow writing theses and articles. But there was no time for a thorough study and the craters would be left open. As soon as he would go, chance visitors and the wind and rain would ruin them. No. 4 had already been ruined in this way and Reinvald did not want to see the same thing happen to Nos. 2 and 5. He felt he was not entitled to take the risk, that he did not have the right to deprive future investigators of the opportunity of seeing them. Nature had not made them for him alone.

"We can't dig any further," he explained to Lillo. "We must preserve them for the scientists who will continue our work."

"Damn it," Lillo growled. "Do you seriously imagine anybody else will spend time digging in these holes?" A gust of wind rustled in the nut-bushes. "Hear that? Even the devils and the mermaids are laughing at us."

That same evening Reinvald carefully planned everything that he had to do in Lake Kaali.

First he had to examine the rocks forming the sides of the lake. They had been thrown out of the lake and many interesting facts were to be learned from them. Then there was the alluvium in the lake itself. If it was as old as the lake the plant imprints in it could tell when the craters were formed. What about Nos. 2 and 5? He had not finished excavating them, but that was not difficult to do. He trusted his successors would survey the craters with a magnetometer, study the bronze artifact found in No. 5 and dig farther into ancient history. He was sure that the ancients knew something about the Saaremaa meteorite and had composed legends about it.

Such was his injunction to the future investigator. He knew he would be unable to complete the work–his health was beginning to fail him and he had no money.

WIND OF CHANGE

No sooner had a police circular stating that it was "indesirable for the politically unreliable geologist Reinvald to be retained in government service" arrived at the Mining Department, than Kuusalu summoned Reinvald and curtly gave him his discharge, ignoring his long service record of almost twenty years.

Reinvald now spent his time looking for odd jobs, and food became a problem in his family. He began to age

quickly, to avoid people, and more and more often shut himself up in his study. For him life was over. He would soon die. But what would happen to Lake Kaali? Within a few decades the craters would be obliterated from the face of the Earth. They would be forgotten. He could not let that happen. He had to save them. But how?

One day he sat down to write a letter. He evidently found difficulty starting it, for he crumpled sheet after sheet.

The letter was addressed to Kulik. Reinvald asked him for help and advice. He told him of his reverses and of his anxiety about the future. His strength was leaving him. He was not afraid of death. He was anxious about the future of Lake Kaali. Who would look after it? Only Kulik He asked Kulik not to forget Lake Kaali if anything happened to him.

"I am leaving my work to you. I am sure you will save Lake Kaali," he wrote ending the letter.

Though the letter was written, it was not simple to post it. On the envelope were the letters "U.S.S.R.". In Estonia people were arrested for even saying something in favour of the Soviet Union.

But the letter had to be posted. Reinvald remembered there was a letter box in the secluded end of the narrow Viru Street, where a round tower, the remains of an ancient wall, stood. That street was far from where he lived and nobody would know, for there was no return address on the envelope. He realised, of course, that this piece of childish stratagem would deceive no one, for the envelope could be opened. But it was easier to post this letter here than in Nõmme.

At a shop window he looked about him. There was a click as the envelope fell into the iron letter box. "That's that. Nobody's seen me. What'll be will be."

He crossed to the other side of the street.

"Faster, faster. I must get away from that letter box."

Reinvald walked as in a dream. He did not look at the passers-by and did not listen to the city noises.

Factory sirens suddenly rent the air on that hot, dry morning.

Reinvald stopped in alarm.

"What's that for? The morning shift began work long ago."

Workers carrying flags and posters marched out of the narrow streets. Cars were forced to the curb. Faces looked out of the windows. The ancient, silent houses became filled with thousands of voices.

"Who collected so many people?" Reinvald wondered. "And where are the police?"

Instead of police constables he saw men with red armbands on their sleeves.

He moved with the crowds to Svoboda Square, which seethed with people. All eyes were fixed on a platform where a man stood. He waved a flag and everybody fell silent. In the stillness his words could be heard clearly:

"We demand the expulsion of fascists from the government. We demand the release of political prisoners. We demand...."

Thousands of voices roared in approval.

"All those in favour raise your hands," the speaker said.

There was an enthusiastic response.

The demonstration moved in the direction of Kadriorg

"Where're they going?" a stranger asked Reinvald.

He did not know where the demonstration was headed for, but he hurried home to tell his family what he had seen.

He realised that a new life was beginning for his country.

In June 1940 the Estonian people overthrew the fascist dictatorship. Their newly-elected State Duma, complying with their wishes, proclaimed Estonia a Soviet Republic.

In August of the same year Estonia was accepted in the U.S.S.R. as an equal republic.

The demonstration that Reinvald witnessed when he went to post his letter was the beginning of these events. Tallinn buzzed with excitement.

THE LAST DAYS

Reinvald was given the job of mining inspector. What he had spent years looking for and mapping had at last found its solicitous master. He gave all his energy to his work.

That day he took a map home with him. He had just seated himself at his desk when Lydia came into the study.

"A letter for you," she said.

On the envelope the return address was: "L. A. Kulik. Academy of Sciences. Moscow."

He quickly opened the letter: "... things could not have turned out better. You, our dear friend, and your Kaalijarv are now on Soviet territory. We are your kin. The Academy of Sciences of the U.S.S.R. undertakes all the expenses of continuing the investigations and preserving the meteorite craters. . . ."

Reinvald was asked to send a plan of work without delay and was informed that he would have air photographers, botanists and soil scientists at his disposal and that the Academy would send him the latest boring machines and magnetometers.

He was overwhelmed.

Not long ago he thought he would never again witness excavations in Lake Kaali. Now he would study the craters as long as his strength held. Everything had been decided without endless petitions, by one letter.

That same evening he wrote an answer:

"I rejoice at the opportunity that only recently seemed so remote. I can hardly believe that my experiments have the support of the Academy. I have never been coddled by the government."

He elaborated his ideas and suggestions for the further study of the craters. "I consider the protection of the craters against destruction as the first and most urgent step."

Together with the letter he sent a tiny parcel to Moscow. It contained meteorite fragments carefully covered with cotton wool. They were his most precious possession.

That year Kulik was hatching out a new plan for a search of the Tungus meteorite. But he was interested in meteorites everywhere else in the world and was overjoyed to receive the parcel from Tallinn.

"It was very opportune," he wrote, thanking Reinvald. "I received the meteorite fragments just as I was going to the Society for the Protection of Natural Monuments. After a report on Lake Kaali I read your letter and showed those pieces of non-terrestrial iron. Everybody was impressed."

Kulik did not limit himself to reports on Lake Kaali. He decided to go to the island and see everything for himself. But would Reinvald misconstrue his intentions? Would he regard this decision as an infringement of scientific etiquette? Kulik wrote a letter: "Although circumstances are forcing me to take a direct part in your quests, I always bear in mind that you have pioneered the Saaremaa discovery and that only you can head the excavations and see the work to its conclusion. I shall only be one of your assistants."

"I shall welcome your help," Reinvald replied. "You and the entire team of scientists will find it best to come during the warm, sunny season."

While preparing for his departure for Saaremaa, Kulik waited for further communication from Reinvald. But Reinvald was silent. Kulik wrote letter after letter. But no reply came. He could not understand it. What could have happened?

...In the autumn of 1940 Reinvald set out for Saaremaa as soon as he received the first instalment of the money

allocated for his investigations. Cold, piercing winds blew and the ground was held in the grip of frost. The boring machine operators tried to persuade Reinvald to return home, to postpone the excavations until spring. But he paid no attention. He had waited too long to start work to bother about bad weather and the frost. But one morning he failed to turn up for work. He had a pain in his back and chest.

He was taken to Tallinn. But there was no improvement in his condition.

On a day that he felt worse than usual he received a letter from Moscow. Kulik informed him that he had been elected a member of the Committee for Meteorites of the Academy of Sciences of the U.S.S.R.

"Can it be true? Can it really be true?" he said, rereading the letter again and again. He was not used to honours and attention. From the moment he had dedicated himself to Lake Kaali he had never been elected anywhere and his work had not been marked by anyone.

Lydia entered the room. Her husband's eyes shone with excitement and he tried to sit up.

"Read this," he said, giving her the letter. "I must answer it at once."

He asked her to help him sit up. When she brought him paper and a pen he tried to write, but fell back exhausted after writing the first few words.

"Let me do it," Lydia offered.

"No," he shook his head, "I'll do it myself. I'll write it as soon as I get out of bed."

But he never got up.

He died in April 1941.

In the meantime Kulik continued his preparations for a visit to Saaremaa, planning to go to the Tunguska River from there in the summer of 1941. Learning of Reinvald's death he put off his trip to Saaremaa until the autumn That plan never materialised. The war broke out.

EPILOGUE

A team of geologists arrived at Lake Kaali one morning in the summer of 1954. They came not with spades and picks as Reinvald used to come, but with the latest types of instruments and apparatuses.

This was the first expedition to Saaremaa without Reinvald. But he was there in spirit—the excavations proceeded according to his plan.

The team was led by Ago Aaloe, a young geologist. With him were scientists and students, the successors Reinvald knew would follow him and to whom he had left his plans and ideas.

It was for them that he had filled and preserved craters Nos. 2 and 5. Aaloe concentrated first on No. 5. The geologists cleared the floor and examined the rocks and earth lying on it. They soon reached disturbed lumps of dolomite. Beneath these lumps was powder, and farther below untouched strata of rock. Reinvald had followed this same "path" but had not reached the bottom. Now it was reached, and the geologists found a blind vent in it. This further trace of the meteorite, this further "autograph", was very similar to what Reinvald found in crater No. 4.

The track measured only 60 centimetres, which meant that the fragment that hit the Earth was not big. The crater, however, had a diameter of 13 metres. This meant that the meteorite had exploded. Nothing else could have made a crater of this size. Reinvald had spoken of an explosion. Aaloe confirmed Reinvald's hypothesis.

Among the rocks filling the crater Aaloe and his associates found numerous tiny meteorite fragments. Though their iron crust was uneven, clay-pitted and cracked, they were nevertheless attracted by a powerful magnet. Within a short space of time 450 grams of meteorite iron were collected. Reinvald who spent ten years on his investiga-

tions had found only a quarter of that amount. But that was understandable—he blazed the road.

Reinvald believed that there were fragments not only in the craters themselves but also in the ground around them. Following up this theory the geologists began their hunt, digging eight wells round the craters and carefully sifting the soil. The wells south and south-west of the craters yielded fragments. The conclusion was obvious: the rocks blown up by the explosion were scattered in a southerly and south-westerly direction.

Old Lillo had assured Reinvald that the mermaids mocked at him when he spoke of others coming to investigate Lake Kaali. Lillo had been wrong again. If mermaids really lived in Kaalijarv they would now have fled from the lake, scared away by the extensive scientific work that was started there. We only spoke of some aspects of that work.

Reinvald was sure that there were myths and legends about the giant meteorite that dug the deep craters on Saaremaa. Professor Kovalevsky of the Ukraine provided the solution to this problem.

In Greek mythology Phaëton, son of Helios, disobeyed his father and drove off in his gold chariot. He failed to control the mettlesome horses and the chariot burst into flames and plunged to the earth. Large cities were destroyed, forest-clad mountains were enveloped by fire and the water in the rivers boiled. Phaëton, his curly hair burning, fell into the Eridanus, far from his home.

Professor Kovalevsky wanted to know what natural phenomenon served as the foundation for the myth about Phaëton. He read ancient philosophers and writers.

In Plato's dialogues he found a note which showed that this myth was based on facts, namely "on deflected bodies moving near the Earth and on the destruction by fire at long intervals of everything on Earth".

This and other notes as well as eye-witness accounts

of heavenly stones falling on Earth led Kovalevsky to the surmise that the myth about Phaëton was based on the fall of a meteorite.

Where did Phaëton fall? Where was the Eridanus? After reading through many ancient books, legends and myths, he came to the conclusion that the West Dvina was called the Eridanus in the remote past. Phaëton's grave is, therefore, in the West Dvina. Kovalevsky believes that the myth about Phaëton is most likely based on the fall of the Saaremaa meteorite.

What happened to Reinvald's collection? For a long time the Committee for Meteorites believed that it was lost. When the war broke out Reinvald's sons enlisted in the army, and his wife and daughters were evacuated to a town in the east of the Soviet Union. But when the war ended Lydia Reinvald brought a small box filled with meteorite fragments to the Committee. It was among the few things that she had taken with her when she was evacuated from Tallinn. The bronze artifact found by Lillo was among the stones. The archaeologists who examined it dated it to the ninth-twelfth century.

This does not refute Reinvald's surmise that the craters had been dug up a thousand years before our era. But the craters themselves contained no proof of this. On the other hand, the small bronze plate is evidence that Lake Kaali interested people in the Middle Ages.

The fragments of the Saaremaa meteorite found by Reinvald are now in the Museum of Mineralogy of the Academy of Sciences of the U.S.S.R. The data collected by him are used all over the world by scientists studying meteorites and meteorite craters. These data are also needed by the builders of interplanetary rockets and spaceships. The Saaremaa meteorite is helping geologists to study the structure and composition of the Earth and astronomers to study the structure of the Universe. Reinvald's discovery is serving people.

Lev Uspensky and Kseniya Schneider

TOWN WITH A DOUBLE BOTTOM

Demeter's "Blanket"

Kerch, which stands on the eastern tip of the Crimea, externally resembles all other busy southern port towns. Its streets run up and down a steep mountain. It has modern esplanades and boulevards. And through the spaces between the houses one gets glimpses of the blue sea. The town has a huge iron and steel works and numerous workers' clubs. The many schools hum with the voices of children.

Like all other towns in the Soviet Union, Kerch is continuously growing in height and width. Tower cranes are used to lay new water mains and build houses. This is the picture one sees everywhere in the Soviet Union.

Yet in some ways Kerch is unique. In the very heart of the town, in Chetvertaya Predelnaya Street behind a fence a narrow passage leads underground. Deep in it is a door with a board bearing the legend "Demeter's Vault". This intrigues you and you want to go in. But a watchman tells you that he has orders to keep the door locked, and that he opens it only once every ten days for an archaeologist.

"What's kept in there? What does the archaeologist do?" you ask the watchman.

His cryptic reply: "Changes the blanket", leaves you very much in the dark.

He walks away and you gaze at his retreating figure in complete bewilderment. What blanket? Why was it being changed? What had Demeter to do with it?

You feel you will have no peace until you see everything with your own eyes. You decide to be on the watch for the archaeologist and ask him for permission to peep into the mysterious vault.

In the meantime you arm yourself with patience and read the lovely myth about Demeter, the goddess of the Earth, who wandered among mortals in search of her young daughter Persephone, who was carried off by Pluto, god of the lower world.

Although you reread the legend several times you find no mention of a blanket.

Then, at last, comes the day when the archaeologist, a young girl, kindly lets you enter the vault. The first thing that you look for is a blanket. On a wooden trestle in the centre of the vault you see a very ordinary quilted piece of fabric. Nothing else. But when you raise your head you see a face with grimly compressed lips and large, sad eyes looking down at you. It is Demeter. Painted two thousand years ago, this superb fresco is what the scientists are guarding so closely in this vault, protecting it against the dampness, the movement of air and careless handling. The "blanket" on the trestle absorbs the destructive dampness and is changed every ten days.

You have learned the secret of the vault and, of course, now want to know some of this town's many other secrets.

You have probably seen old caskets with double bottoms. They may have contained balls of wool, buttons or pencils, or were used as a medicine chest, while the secret

bottom, opened by a spring, held a packet of time-worn letters tied with a ribbon. What was in these letters? A love story, the secret of two hearts that had stopped beating long ago? Kerch, a bustling port with a host of solved and unsolved mysteries in the ground on which it stands, is like one of these secret caskets.

Let us, therefore, press the spring that releases the bottom and take a look at what was once Panticapaeum, capital of the Bosporan Kingdom.

PANTICAPAEUM

Books by ancient historians and writers tell us that there was once a mighty kingdom on the Cimmerian Bosporus, now known as Kerch Strait. It was described by Greek, Roman and Eastern scholars who were its contemporaries. It has been and still is of special interest to historians, for this kingdom, which existed for a whole millennium, was extremely unusual, and its rise, development, bloom and destruction conspicuously exceptional. However, much about it remains unsolved and incomprehensible.

The information given us by books has frequently proved to be contradictory and inaccurate. The traces of this kingdom had to be seen and studied and the testimony of the ancients verified before any final conclusions could be made. Archaeology was needed. But as a science it had not yet been created.

In Panticapaeum excavations were first started in 1816 by Russian scholars. In those years everything in Kerch had the halo of antiquity about it. Potsherds were scattered about the ground everywhere. Stone slabs with antique inscriptions were to be seen in the walls of modern buildings. Ancient coins and valuable statuettes were found on the ground. But there were innumerably more relics in the ground.

In the face of the law of private ownership it was not easy for archaeologists to begin their work. They had to depend on the whim of the landlords.

A householder in Kerch discovered a painted vault while digging in his kitchen-garden. The picture on the wall, skilfully drawn, was of a nomad yurta and beside it a woman sitting in an armchair with servants standing near her. On the right an armed horseman with a whip in his hand was riding up to the yurta, followed by another horseman with a spear atilt. Over the picture an inscription in Greek read: "Anfesterius, son of Gegesipp, also called Ktesamen".

It was a remarkable picture in every respect: the bright colours and the somewhat obscure content. Who was Anfesterius? Why was he portrayed near the yurta? The Greeks never lived in yurtas, but judging by the name and the appearance of the man himself Anfesterius was a Greek. Who had he come to see? For what purpose? Who was the woman? This vault had to be preserved for science. But that was not simple to do. While scientists applied to the authorities, the owner of the kitchen-garden and, consequently, the vault, scraped the rare picture from the wall with a spade. The vault lost its value to science and could now be used for the storage of potatoes and pickled cucumbers. Luckily, an artist named Gross had made a copy of the picture. But it was a poor substitute.

Archaeologists had other difficulties and disappointments. From time immemorial human greed had wandered about old cemeteries, penetrated the silence of temples buried in the ground, dug holes and broke into tombs. Ancient burials were plundered by Alans, Sarmatians, Goths, Huns, Tatars and Genoese. When archaeologists began their work, they found that most of the Bosporan tombs and burial mounds had been despoiled. This underground museum proved to be half-ruined. Moreover, archaeological excavations awakened unhealthy passions

among the local population. There was a rumour that treasure consisting of hundreds of objects made of pure gold had been discovered by scientists in the tomb of a Scythian king in the Kul-Oba burial mound. The whole of the Crimea became infected by the fever of treasure-hunting. People began to dig in the ground as though they had lost their reason. In the hope of finding riches they broke up tombs, destroying priceless Helladic amphorae and statuettes and scattering the remains of warriors, chieftains and slaves. They were not interested in anything except gold The archaeologists looked on with horror as this horde of modern barbarians swooped down upon the property of science.

But there were a few things that the scientists could do. Some of the marauders were civilised. They knew that besides gold there were other things to look for in the ground. They appreciated the value of antique works of art and wasted no time when there was a clay amphora, a bronze seal with the head of Apollo or some other relic to be dug up. A large number of these antiques were sold abroad.

Besides, in those days many archaeologists did not go about their work correctly. They valued chiefly works of art, which they sent to museums and described in their reports. Potsherds, pieces of worked stone or wood, charred scraps of fabrics, and grain at the bottom of amphorae were thrown away as worthless.

Today the situation is quite different. Among the notes of a modern archaeologist, we find entries such as:

"... at a depth of 67 centimetres we found:
nimbus of a plate 1
headless bronze nail 1".

Yes, that is exactly what it said: "headless nail". It was dug up, recorded in the diary and stored in a box. It, too, is regarded as valuable.

Everything has changed. The days of the "gold rush" are over. The land belongs to the state and no excavations may be conducted without the knowledge and direction of scientists. No object, no matter how trifling, is thrown away. Gold ornaments and precious vessels are valuable and important, but a simple potsherd sometimes brings the archaeologist as much joy.

An entire forgotten world gradually rose out of the siliceous soil in Kerch. It consisted not of the "traces of streets" and "half-buried moats" that the poet Alexander Pushkin saw when he passed through this region in 1820, but at least ten towns and settlements that once surrounded Panticapaeum with their temples, squares, baths, gymnasiums, distilleries, fish-salting yards, markets and cemeteries. Names long forgotten and smacking of Homer and Herodotus, such as Nymphaeum, Partheneum, Achilles and Myrmecium, came to life again.

And bracketed with them are other names—Tirytaka, Korokandam, Cimmerik—telling us of Scythians, Sarmatians and Cimmerians.

BOSPORAN KINGDOM

Daredevil Greek seafarers began sailing into the Black Sea seven centuries before our era. It would be wrong to call them travellers, for it was not for the sake of science or knowledge that they undertook long and dangerous voyages. Their aim was trade and profit. They were merchants and pirates or, frequently, merchant-pirates, because in those days piracy was not dishonourable. Nonetheless, there were among them courageous and talented men who thirsted for knowledge, and their stories of what they saw and heard were often used as the basis for books by ancient historians.

To these people, who came from the sunny shores of the Aegean, the Black Sea looked stern and forbidding. Danger lurked all along their way. Savage Tauris* attacked the Greek vessels, looting them and killing the crews with clubs or throwing them into the sea as a sacrifice to their gods. But the Hellenes doggedly sailed to the shores of this strange sea, which they called Pontus Axinus or Inhospitable Sea. However, the inhabitants of the Crimea and the territory deep to the north of the continent, the mysterious nomad and semi-nomad Scythians, did not prove to be as savage as the Greeks thought they were. They willingly bartered grain, hides, wool and fish for beautifully-made weapons, ornamented vases, grape wine and olive-oil. The Greeks prospered rapidly and soon made their most important discovery—the land of the Scythians was remarkably fertile and the climate was not as severe as they had at first thought.

In Greece herself life was not a bed of roses for many of the people. Some were land hungry, others were prevented from trading or engaging in handicrafts by the wealthy and the nobility, and still others were implicated in uprisings and forced to flee to the Scythians, who, evidently, were quite prepared to let the Greeks settle on the seashore.

At first the Greeks built small settlements around anchorages. Soon these settlements grew into towns, and the Greeks renamed the Black Sea into Pontus Euxinus or Hospitable Sea.

These Greek colonies on the northern shore of the Black Sea were described by Cicero as "being a border sewn to a vast fabric of barbarian fields."

Wise Plato did not use such flowery language but his description is in no way less image-making. The Greeks,

* Ancient inhabitants of the Crimean Peninsula. They are mentioned in fifth century B. C. Greek sources.

he wrote, "settled on the shore as ants or frogs round a pool."

As time passed these colonies united to form the powerful Bosporan Kingdom that flourished for ten centuries. Throughout those centuries the Greeks and the Scythians lived side by side, now bitterly hostile, now making peace, influencing each other and jointly creating a unique culture that combined many Greek and Scythian features. Today we call it the Bosporan culture. Soon the people themselves became known as Bosporans. Their kings and military leaders had now a Greek, now a Scythian, now some other barbarian name and in many cases historians find it difficult to determine whether the founder of one or another royal dynasty was a Hellene, Scythian or Sarmatian

Proud Athens received her grain from the Bosporan Kingdom when it was at the height of its prosperity. Then came wars and uprisings. Enemies and elemental calamities destroyed the towns, but the stubborn Bosporans kept bringing them back to life. Century after century, layer after layer was buried by the soil, which hid temples and hovels, and treasure-troves of coins and gold ornaments concealed by Bosporan noblemen during invasions or sieges Children buried their fathers, placing lacquered vases and gold-ornamented weapons in the deep vaults. The high burial mounds hid the treasures of the Scythian graves. The earth was turned into a storehouse, into a fabulously rich museum of antiquities. Today scientists are continuously finding these underground storehouses and seeking in them answers to many questions. Much is unintelligible to them in this rare alloy of highly-cultured Greeks and barbarians, about whom Herodotus wrote: "They drink the blood of their first victim and are rewarded in accordance with the number of enemy skulls they throw to the feet of their chief."

CITIES OF THE DEAD

Isn't it really astonishing that a city of the dead, a necropolis, should tell us about the living? While excavating burial mounds and raising the heavy slabs from ancient tombs, archaeologists find not only human skeletons but also the skeletons of animals, weapons, household utensils, valuable works of art, fishing hooks, spindles and toys. In those days it was believed there was life beyond the grave and the dead were therefore generously fitted out for that life.

The strongly built vaults, stone-lined graves and sarcophaguses were designed to protect the deceased and his property from destruction. It was natural to expect that on the territory of what was once the Greco-Scythian Bosporan Kingdom there would be Greek and Scythian graves and that the difference between them would be as great as was the difference between these two cultures. The Hellenes did not kill the wives and slaves of the deceased. They did not put his favourite horse in the grave with him. The Greek burials did not contain such a vast number of objects or such fabulous wealth as was found in unpillaged burial mounds of Scythian nobles. Grecian burials usually contained an inscribed stele with a sculpture of the deceased. In almost all the male burials there was near the skeleton a small jar of oil with which the Greeks used to rub themselves when they prepared for exercises in a palaestra,* and an iron scraper with which to scrape off the oil after these exercises. Amphorae, hydriae and beautifully ornamented jars were placed in the graves but the Greeks evidently did not supply their dead with food, for only in rare cases have dishes with nuts, chestnuts, almonds, apple and pear pips, plum stones and so on been found near the sarcophaguses.

* As distinct from a gymnasium, which was a public organisation, this was a private wrestling school.

The graves of noblewomen yield up lovely jewelry and toilet articles: bronze mirrors, ivory caskets, and tiny jars with the remains of whiting and rouge.

Classical Hellene burials of this kind are found but they are typical only of the first stages of the development of the Bosporan Kingdom.

Even more noteworthy are the kurgans, imposing burial structures, that are helping archaeologists to learn how two such dissimilar peoples united to form the Bosporan nation.

In September 1830 soldiers sent to quarry stone for barracks in Kerch chose a kurgan about six kilometres from the city. It bore the Tatar name of Kul-Oba. Soon after they began digging they struck an ancient tomb. The civil authorities in Kerch were immediately notified and their representative was soon followed by archaeologists. The scientists were overjoyed to find that the vault was untouched. In it they discovered the priceless treasures that formed the nucleus of the famous collection of Cimmerian Bosporus antiquities on display at the Hermitage in Leningrad.

All the objects pointed to the fact that this was the tomb of a Scythian chieftain. They included the remains of a conical felt hat and an iron sword with a gold ornamented handle. The handle design, made in typical Scythian style, was of animals locked in combat, beasts of prey attacking herbivora, and fantastic animals. The most striking indication that this was a Scythian burial was that beside it were the burials of the chieftain's wife and one of his male slaves.

Pots containing sheep's bones, and a few horse's bones were also found in the grave.

Though nobody doubted that the deceased was a Scythian, there was something about the Kul-Oba kurgan that distinguished it from usual Scythian burials.

First and foremost, this concerned the monumental character of the tomb itself, with its stepped roof and pyramidal vault built in the architectural style brought to the Bosporus by the Greeks. Secondly, at least one horse was put into the grave of even the poorest Scythian nomad, while noblemen were buried with scores and even hundreds of horses: the skeletons of four hundred horses were found in one of the burial mounds. The man buried in Kul-Oba possessed incalculable wealth. This was shown by the numerous luxury articles in the grave. However, with the exception of a few bones, no trace of horses was discovered in the burial mound. This may be due to the fact that Hellenic culture had compelled the man's relatives to reject some Scythian customs.

The influence of Greek culture is to be seen mostly in the luxury articles. Here is a description of a female burial from Professor Gaidukevich's *Bosporan Kingdom*:

"Her painted cypress-wood sarcophagus was ornamented with ivory plates some of which were exquisitely engraved and partly decorated with figures. On her head she wore a diadem with its upper edge spangled with rosettes decorated with blue and green enamel. Below them the diadem was decorated with palmettes alternating with winged demons and griffins.

"On her skeleton were three beautifully made gold pendants and also a pair of larger gold pendants with medallions with the helmeted head of Athena, reproducing the head of the gold and ivory statue of Athena Parthenos wrought for the Parthenon by Phidias in the 440's B.C."

Then follows a description of bracelets, rings, necklaces and clothes covered with gold plates "of which there were several hundred".

This woman was fashionably dressed in the custom of the Greeks. True, she was dressed only in order to be strangled. This, of course, had nothing to do with Greek custom. The cult of the dead was evidently still widespread.

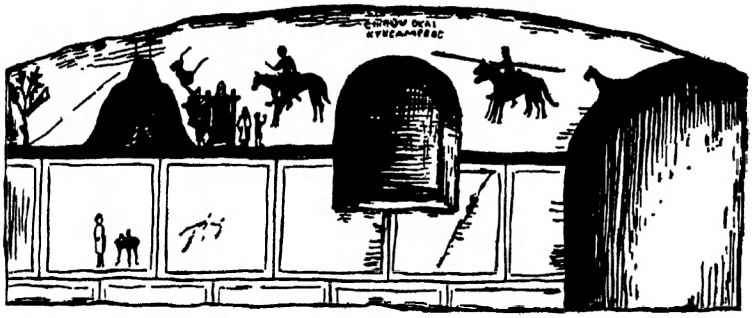
Later Scythian burials in the Bosporus did not contain either strangled women or slaves.

In a vault discovered in the Bolshaya Bliznitsa kurgan, which was undoubtedly the burial of a Demeter priestess, the only indications that the deceased belonged to the "barbarian" nobility were the splendour and wealth of the burial itself and the bridles, saddles and decorations for horses.

But let us return to the Kul-Oba kurgan. The numerous gold, silver and bronze jars, cups and amphorae found in it included a vessel made of a precious alloy called elektron* by the Greeks. The picture on it evidently depicts two friends. One is treating the other's jaw. By the expression on the sick or wounded man's face we know that he is in pain. He holds his friend's hand in the same way as we sometimes catch hold of the dentist's hand. Their beards, long hair and belted clothes make it obvious that they are Scythians. This piece of toreutics was obviously made by an artist who had studied the people he had portrayed on the vessel. Such a faithful likeness could only have been achieved by a man who lived among Scythians.

A lovely silver amphora was found in the Chertomlitsa kurgan near Nikopol. In its lower part, between the embossed lion's masks, are a number of holes with silver plugs. The purpose of these holes was to enable the deceased to drink the wine in the amphora. On its shoulders are silver figures representing a scene in which men are rounding up horses grazing in the steppe; two of them are using lassos, one is hobbling a horse, and another holding a horse by its tail. By their faces and clothes we can see that they are Scythians. Both the Kul-Oba and Chertomlitsa vessels were unquestionably made in Panticapaeum, possibly by a Greek.

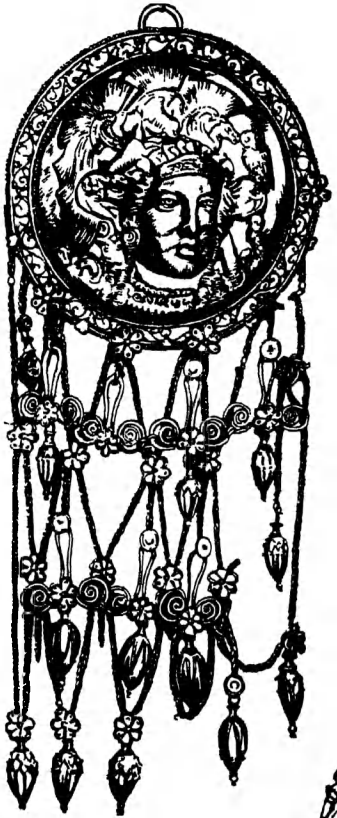
* This alloy of gold and silver had an amber hue, hence the name *elektron*, meaning amber.



First century A. D. wall painting in the Anfesteria Vault, Kerch

Entrance to Demeter's Vault, an early Christian burial with splendid wall paintings, in Kerch

Demeter fresco from a vault in Kerch



Earring with the head of Athena

Silver amphora from the Cher

ordinary people than what the ancient historians tell us. The poor burials of farmers and artisans provide scanty information, and archaeologists are compelled to move from the necropolises to the ruins of the antique Bosporan settlements, towns and townships and dig in places where many generations of freemen and slaves, of people of all walks of life lived, worked and died. This is the field in which Soviet archaeologists are particularly active.

TOWNS OF THE LIVING

An archaeological expedition headed by Professor Gaidukevich conducts systematic excavations in Tirytaka, Myrmecium and the antique fortress of Ilurat near Kerch.

It is hard work excavating settlements: articles of value seldom occur in the ground. Here the archaeologist finds chiefly ruins of buildings, potsherds, fish bones and charred wheat, barley, millet, lentils and peas. One of the finds, however, was a small bronze rod with a flattened end. When it was cleaned it was found that the other end had a bulging image of Aphrodite that matched this goddess' figure on the gold medallions worn by the Bosporan nobles buried in vaults. It turned out to be the die from which these gold medallions were struck. This meant there were jewellers and, perhaps, workshops in Panticapaeum itself and in a small town of fishermen and artisans about ten kilometres away.

From the records left to us we know that the Bosporans bought their wine in Greece, receiving it in large amphorae. According to antique writers, the Scythians drank this wine undiluted. "To drink as the Scythians" meant to drink hard. For a long time it was held that the Bosporans were unable to grow their own vine because the climate was not warm enough. But this belief was upset following the discovery of distilleries with wine presses, drains and

reservoirs dug into the ground, bricked and plastered. Each of these reservoirs could hold up to 5,000 litres of grape juice. The juice was put in huge earthenware pithoi, where it turned into wine.

Distilleries have been found in Panticapaeum, Tirytaka and Myrmecium. The Bosporan wine-makers learned to manufacture improved presses for grapes that had already been pressed with feet. These distilleries show that there were vineyards around Panticapaeum, while the plum and cherry-plum stones tell us that this area had orchards. Stone grain-crushers, handmills, and grains of wheat found on the bottom of earthenware vessels are an indication that wheat was grown in the Bosporan Kingdom.

Greek historians are quite explicit about the Black Sea abounding in fish. The fishermen and fish-salters to whom Archystrates dedicated an essay on Bosporan salted fish probably lived in Tirytaka, where archaeologists have unearthed large fish-salting vats, numerous bronze hooks, plummets and a vast quantity of bones. The Greeks wrote that the sturgeon caught in this area were "almost as large as dolphins".

However, the Cimmerian Bosporus owed its glory, wealth and power not to wine or fish but to grain. We know this from antique writings, documents, inscriptions on stone and archaeological finds. Small wonder that Demeter, goddess of the soil and agriculture, was the most venerated deity.

The Bosporan rulers skilfully utilised the difficult food situation in Athens to strengthen their trade and political relations, enhance the prestige of the Spartacids and turn the Bosporus into a rich, cultured country. An extremely interesting document showing this activity has come down to us. It is a speech made in the year 393 B.C. by an Athenian orator named Isocrates on behalf of a Bosporan merchant in a lawsuit against an Athenian banker named Pathion.

This merchant, a young man, was the son of a rich Bosporan grain trader and shipowner named Sopius, who at that time held high office in the government and was on friendly terms with King Satir I himself. Historians are of the opinion that Sopius was a Hellenised barbarian. Wishing to give his son a Greek education and help him amass an independent fortune, Sopius sent him to Athens with two ships loaded with wheat. It may be surmised that he gave him quite a lot of money.

As soon as the son arrived in Athens he deposited the money in a bank. It was safer there and, besides, would yield an interest.

We do not know how well the young merchant did in his studies in Athens, but it is a fair guess that he did not have a bad time. Suddenly, like a bolt from the blue, the king himself directed him to return home and surrender all the money Sopius had given him. The king, it was learned, had ordered his friend Sopius' arrest on a charge of high treason. But the son kept his wits about him. He came to a secret understanding with the Athenian banker and promptly declared that he had no money.

Before long news was received that the king had made his peace with Sopius, restored all his rights and married the merchant's daughter to the young prince Levkon. That was when the banker showed his claws, declaring that Sopius' son had never deposited any money in his bank. A lawsuit in which the Bosporan king himself intervened was started. Messages were sent back and forth between the Bosporus and Athens. The banker sent his representatives to Panticapaeum to protect his bank's interests, while the king called together a council of prominent merchants to protect Sopius' rights. In the speech Isocrates made in court he expertly flattered the Bosporan king and Sopius and also all Bosporan merchants, reminding the Athenians that they had always been supplied with wheat even when

the requests of merchants of other countries had been turned down.

We do not know how the case ended. But then the important thing is not whether the king's favourite merchant succeeded in adding the money embezzled by the banker to his already swollen coffers. What interests us is that Isocrates' speech gives us an idea of the relations between Athens and the Bosporan Kingdom when it was at the height of its glory.

The powerful Bosporan kings were honoured in faraway Athens. Their statues were erected in the city and edicts lauding them were inscribed on marble slabs and displayed at busy street corners. The calculating Athenians managed these matters adroitly. It did not cost them very much to crown the Bosporans with gold wreaths. They had an agreement with the Bosporan kings that all these pompous awards would be dedicated to Pallas Athens, thus committing them to the custody of that goddess' temple in Athens itself. This arrangement pleased everybody: the king received honours and the city bore practically no expense.

SAUMAK, LEADER OF THE OPPRESSED

Today everybody knows that archaeologists hunt for antique relics not for themselves but for science. Still, many people are surprised that frequently a magnificently minted antique gold coin inspires less delight than a tiny, worn copper or bronze coin. The reason for this is that in many cases similar gold coins are to be found in museum collections, while the copper coin may be the only one of its kind. Moreover, it may prove to be the missing link of some daring theory.

One such coin started an argument that continues to this day. On it are only four Greek letters: sigma, alpha, upsilon, mu. What do they stand for? A name? Part of a name? Or, perhaps, Saumak?

An uprising led by a royal Scythian slave named Saumak broke out in the Bosporan Kingdom in the second century B.C. Antique historians wrote very little about this uprising, but from an inscription on a statue we know that the insurgents captured Panticapaeum and Feodosia. The king's forces that were thrown against the insurgents were commanded by Liophantus, in whose honour a statue was later erected. The inscription on the pedestal briefly recounted his battles against the insurgents.

The preparations to send a punitive force against Saumak took six months. But a whole army and the country's navy had to be brought into the fighting before the uprising was crushed. Saumak was captured and executed. If the letters on the coin stand for Saumak, the implication is that the leader of the uprising had facilities for minting coins. But are four letters sufficient grounds for such a conclusion? The other side of the coin portrayed Helios, the sun god, with rays around his head. Does this mean anything to historians?

The uprising in Panticapaeum was preceded by a rebellion in Pergamus, where the insurgents called themselves Heliopolites or citizens of the sun. Saumak, naturally, knew of this rebellion. When he became the ruler of Panticapaeum he embodied his dream of creating a happy land, a land of the sun, by causing coins to be minted with a portrayal of the sun god. Such is the opinion of most scientists. But this theory can only be proved by finding a coin with Saumak's name inscribed on it in full.

STATE-PROTECTED EXCAVATIONS

There are cities in the Soviet Union where life centres around giant factories. One of them is Magnitogorsk in the Urals. Other cities, like Sevastopol and Kronstadt, are centred round a harbour and port. In Kerch the tone is set by the Archaeological Museum.

Here the problem of town planning is just as complicated as it is to live in an ancient palace, where the wallpaper may be hiding a priceless fresco or the floor guarding a secret archive. In Kerch houses have to be built on ground crammed with treasure. If each building site is not explored these treasures may be lost completely. Each stone has to be examined to make sure it is not a valuable tombstone. Here the ground may be hiding an ancient burial vault, there the remains of Grecian baths, a gymnasium or a market. For many years archaeologists have been unsuccessfully looking for some trace of the Panticapaeum theatre, which is known to have existed. It is mentioned by ancient writers. There is a well-known story according to which a Greek ambassador arrived in the Bosporan Kingdom with the spy assignment of learning the size of the towns and the number of the population. He arrived accompanied by the famous actor Aristonicus, who had the task of drawing the citizens of Panticapaeum to the theatre in order to enable the ambassador to count them.

Archaeologists believe that the theatre must be near the ruins of the temple of Dionysius at the foot of Mount Mithridates. Unfortunately this site is now Sverdlovsk Street with large modern buildings and it is no longer possible to learn what lies beneath them.

In new building sites, however, the situation is different. A special government decree gives the Kerch museum the authority to stop any building work at its own discretion. But the museum cannot see to everything. Its staff cannot be everywhere waiting for an excavator to strike a burial vault or the spade of a navvy to hit an amphora. Only a trained archaeologist can tell if the stone scooped up by the steel bucket of an excavator was worked in antiquity, whether the digging should continue or stop. The museum could not assign an archaeologist to every excavator, so the solution lay in making all the people in Kerch archae-

ology conscious. That is exactly what was done. Today workers on building sites, schoolchildren, housewives and other people keep putting through calls to the museum.

All new excavation sites are protected by the state. In them work goes on at all seasons of the year, the task being to preserve everything found accidentally by the people. The museum owes a large part of its valuable collection to this co-operation from the people.

Almost always there is a crowd watching the excavations and frequently an on-the-spot lecture is given by one of the archaeologists.

One of the finds made by builders was a burial containing the remains of a child's skeleton and tiny gold ornaments: a bracelet, ring, earrings, the gold tips of a small belt. It was established that the child was less than a year old. The name Hara was inscribed on the ring.

A staff member of the museum showed all the articles from the burial to the watching crowd, explained the manners and customs of the people who lived here in antiquity, and registered all the finds there and then.

In the course of the many years that the Kerch museum has been conducting its work its small staff of archaeologists has recruited thousands of assistants. They are people of all ages who are united by their love of the history of their town and their pride in the museum.

However, volunteers are not encouraged to touch anything found in the ground, because only a trained scientist can bring it to the surface without damaging it. In Kerch many antiques are brought to the surface by rain or landslides. These finds are what adults and children bring to the museum most frequently.

One of the museum's most active helpers is a pensioner named Yudkevich. Among other things he found a rare sculpture of the Triple Hecate. A worker named Ilyu-

khin found a stele with the figure of a warrior painted on it.

A railway engineer named Veselov has developed such a passion for antiquities that archaeology has almost become a second profession with him. He writes for archaeological journals and actively helps the museum.

WORLD TREASURE-STORE

The Kerch museum's lapidarium is of world importance. It includes hundreds of steles. Only a few marble grave-stones were brought from Greece; most of them were locally made from coquina. Inscriptions, portraits and groups of figures are engraved on these stones. One of them portrays a man and wife holding hands as a sign of inseverability and fidelity. Another shows six children lined up according to height: perhaps they were killed by an epidemic. Yet another shows a woman in a long, flowing robe sitting in an armchair with a youth leaning on a shield beside her. Behind the armchair is a tiny figure. These tiny figures of men and women are to be found on many steles. They are slaves and are portrayed in half the size of their masters.

A staff member of the museum will always oblige by translating some of the ancient inscriptions. One of the grave-stones tells you that the deceased was killed by Ares, the Scythian god of war. Another that the "deceased was struck down by a terrible barbarian spear". You will hear Greek names: Aristipes, Diophantes, Heracles; Scythian names: Ardar, Bastak; a Roman name: Quintus; and a Persian name: Aheimen. You will learn that there were merchants, shipwrights, flute-players, athletics instructors and philologists.

Most of the inscriptions end with the Greek word *"haire"*, meaning farewell. Your guide will read the sad

and simple inscriptions: "My wife, Calia, farewell"; "Feotima, wife of Bacchius, and son Moirippus, farewell"; "Filottus, son of Myrmecius, farewell".

The acropolis of Panticapaeum with its lovely palaces and temples stood on Mount Mithridates. From the foot of the tall obelisk, erected on the highest point in Kerch in honour of the heroes who fell in the battles for the liberation of the Crimea during World War II, one gets a good view of the surrounding countryside that witnessed the birth, glory and death of the Bosporan Kingdom. In the south, beyond the Uz-Oba (Hundred Graves) chain of burial mounds is Tirytaka, once a town of fishermen, wine-makers and potters. Farther south, in a beautiful bay on the seashore are the ruins of Nymphaeum, the town over which Athens and Panticapaeum quarrelled. It was a rich town with the best harbour on the coast and fertile land. At the foot of a cliff in Nymphaeum stood a temple to Demeter, whom the Bosporans revered and the sybaritic Hellenes called the "peasant goddess". The temple was destroyed time and again by war and earthquake, but it was rebuilt after every catastrophe.

In the north we can see the royal burial mound, a miracle of architecture that leaves an indelible impression.

Farther beyond Myrmecium are the small towns of Porphmius and Achilles facing each other across a strait. There was once a ferry between them. Divers working in the vicinity found a valuable Greek amphora on the sea bed and presented it to a congress of archaeologists that was in session in Kerch at the time.

The hill we are standing on is named after the great Bosporan king Mithridates VI Eupator. Legend tells us that after a long struggle against Rome he was betrayed by his own son and committed suicide on a hill in Panticapaeum.

The Romans captured the Bosporan Kingdom, ruling it for several centuries until Europe was overrun by the Huns of Attila, the Scourge of God, until "the grass stopped growing where the hooves of his horse passed".

The millennium-long existence of the Bosporan Kingdom came to an end in the last quarter of the fourth century A.D.

НРОБОУ ПОЗС
ЛДКЪNАТЗН
ЖЄВН

SECRETS OF HISTORY

ARE THERE ANY UNKNOWN ANIMALS IN THE WORLD?

AMID ETERNAL DARKNESS

ATLANTIS

S. K. Klumov

ARE THERE ANY UNKNOWN ANIMALS IN THE WORLD?

Secrets of the Ocean. Giant cuttle-fish and sea serpents. What develops from eel larvae? The "devil" of Lake Labynkyr. Charles Beebe's remarkable discovery. What whalers say. The "wonders" of the Sordongnokh Plateau and Lake Sary-Chelek

We still do not know many things in Nature. Despite science's rapid development, particularly in the past few decades, many places of the Earth remain to be studied. Not all continents have been thoroughly investigated. There are regions where man had not set foot, for example, the jungles in the upper reaches of the Amazon and the Ucayali, certain areas of the Congo, many regions of the world's largest mountain systems, and remote areas of deserts. Man has seen some of these regions only from the air. It must be borne in mind that only 29 per cent of the Earth's surface is land, the other 71 per cent being occupied by the World Ocean. Man began penetrating the ocean's eternal darkness only about 30 years ago when the American scientist Charles William Beebe descended in a bathysphere to a depth of 923 metres.

On the map of the World Ocean there are only a dozen points where man descended to

a depth of over 1,000 metres. There are 1,370,323,000 cubic kilometres of water in the World Ocean. The depth averages about 4,000 metres while the maximum depth is somewhat over 11 kilometres. This entire vast expanse of water, from top to bottom, is inhabited by the most diverse animals ranging from microscopic planktonic crustaceans to whales, the largest mammals ever to exist on Earth.

Little is known of the life of the ocean, for investigations have only just been started.

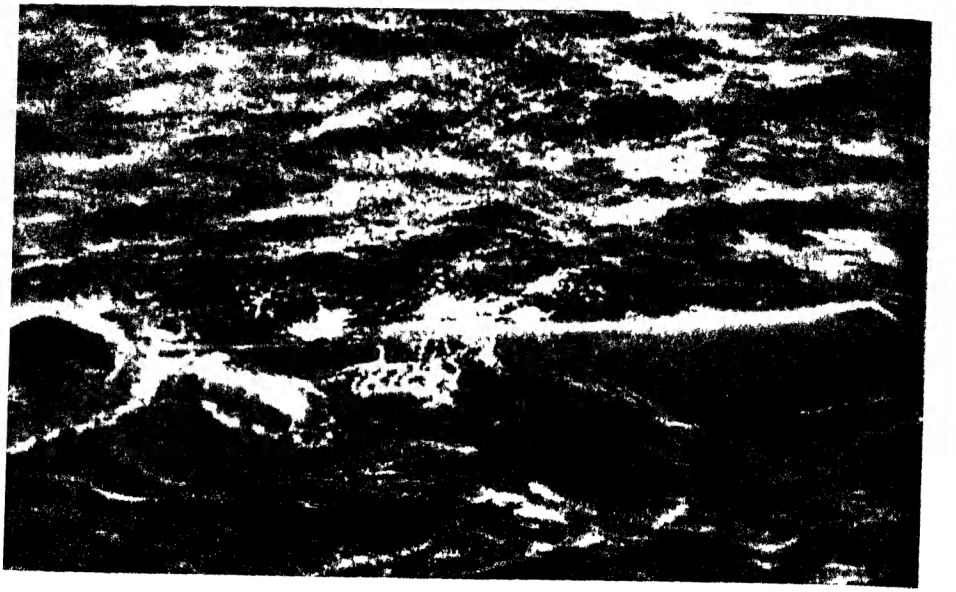
In 1949 the Soviet ship *Vityaz*, specially equipped for marine investigations, trawled the Pacific Ocean at a depth of 7,000-8,000 metres in the region of the Kuril-Kamchatka Trough and proved that there is life on the bed of the ocean even at that enormous depth. During the following years the *Vityaz* trawled the ocean at the maximum depth of nearly 11,000 metres, finding life everywhere. The ship's trawl brought to the surface animals that had never been seen before, enabling scientists to record more than 300 new species of deep-water invertebrates and fish.

However, the technique of catching animals at great depths is still much too primitive to allow us to catch large, fast-swimming animals. All modern fishing gear is designed for small and relatively slow-moving animals. No fisherman has yet caught an architeuthis or giant cuttle-fish, although we know for certain that these fish exist. Pieces by which the size of this living rocket can be gauged have been found in the bellies of sperm whales. Large suckers are sometimes found sticking to the skin of sperm whales as momentos left by the giant cuttle-fish during an unequal struggle for their life. An old male sperm whale, which is about 18 metres long, is naturally more than a match for an architeuthis. Dead cuttle-fish measuring 12-15 and sometimes 18 metres have been washed ashore. But such cases have been rare.

The question before us is whether in addition to mammoth whales and giant cuttle-fish the World Ocean

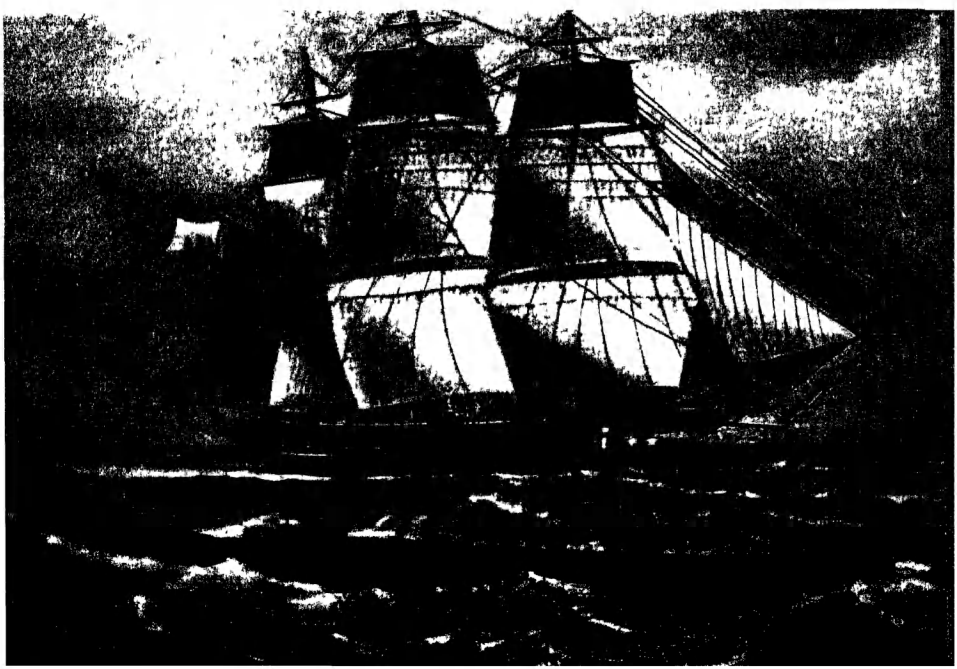
Sea cucumbers found at a depth of about 9,000 metres by the **Vityaz** expedition

Giant cuttle-fish washed ashore near Aberdeen, Scotland

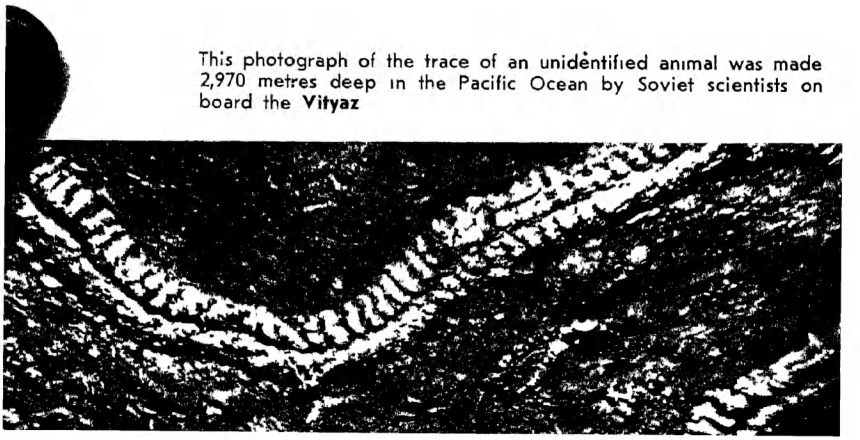


Sperm whales, which hunt giant cuttle-fish

This drawing of a sea serpent as described by the skipper of the **Dedalus,** appeared in the **Illustrated London News** nearly a century ago



Deep-water trawl, lowered by the **Vityaz,** the expedition ship of the Academy of Sciences of the U.S.S.R., brings the dwellers of the ocean to the surface for biologists



This photograph of the trace of an unidentified animal was made 2,970 metres deep in the Pacific Ocean by Soviet scientists on board the **Vityaz**

contains large animals about whom we know nothing. This question may be answered definitely in the affirmative.

The crews of many warships, fishing boats and passenger vessels in past centuries and in the first half of the present century saw the so-called giant sea serpent. According to various sources it is from 15 to 30 metres long. However, no specimen has as yet been handled by man although many people have seen this animal at fairly close range. Several times ship's guns have been fired at it, but it invariably disappeared in the water. The last time it was seen was from the Greek ship *Santa Clara* on December 30, 1947, off the shore of North America 118 miles east of Cape Lookout (about 35° north latitude and 75° west longitude). Here is how the captain describes it:

"Suddenly, John Axelson (the third mate) saw a snake-like head rear out of the sea about 30 feet off the starboard bow of the vessel. His exclamation of amazement directed the attention of the other two mates to the sea monster, and the three watched it unbelievingly as it came abeam of the bridge where they stood, and was left astern.

"The creature's head appeared to be about 21/2 feet across, two feet thick and five feet long. The cylindrically shaped body was about three feet thick and the neck about 11/2 feet in diameter.

"As the monster came abeam of the bridge, it was observed that the water around the monster, over an area of 30 to 40 feet square, was stained red. The visible part of the body was about 35 feet long. It was assumed that the colour of the water was due to the creature's blood and that the stem of the ship had cut the monster in two.

"From the time the monster was first sighted until it disappeared in the distance astern, it was thrashing about as though in agony. The monster's skin was dark brown, slick and smooth. There were no fins, hair, or protuberances on the head, neck or visible parts of the body."

It will be possible to prove the existence of this animal

only when we catch it or get a good photograph. However, there are sufficient grounds for asserting that such an animal exists and that it is a large, eel-like fish.

Let us review the evidence.

First, there are the visual observations at sea. The serpent was seen by many people. Their evidence cannot be discounted because we cannot seriously imagine that all of them, including scientists, were visionaries. Some of them saw these animals moving at very close range. All the descriptions are approximately the same. But there is other testimony.

While descending in his bathysphere near the Bermuda Islands (somewhat south of the spot where the monster was observed from the *Santa Clara* in 1947), William Beebe saw two unusually large sea eel larvae at a depth of 700 metres. He immediately telephoned his observations to his base ship and asked his colleagues to write down his description.

Back in February 1930, when he was still a student, the Danish oceanologist Anton Bruun caught a giant sea eel larva in the South Atlantic during a cruise on the research ship *Dana*. The larva was nearly two metres long. The larvae of the ordinary eel are never longer than seven centimetres during the period of their life in the sea. They develop into eels, the longest of which do not exceed 90 centimetres. Considering that the giant larva was at the same stage of development as an ordinary eel larva and that its growth must follow the same proportions, Bruun maintains that the adult sea eel emerging from this larva must reach a length of at least 20 metres. This coincides with the numerous observations made from different ships. It must be emphasised that giant sea serpents were seen in the South and Central Atlantic, i.e., where Beebe saw the huge larvae and Bruun caught one of them.

Why is this giant sea eel so elusive? The first reason is that it lives deep in the ocean and we do not have the

means of catching it. The second is that probably there are very few of these fish in existence. They swim singly or in pairs (in the mating season) and, possibly, are becoming extinct. In any case, the giant sea eel population is not in a flourishing stage otherwise they would have been seen much more frequently.

Beebe reported that during his descent near the Bermuda Islands he saw more than ten species of unknown fish measuring from one to six metres in length. Here is what Beebe himself says in his book *A Half Mile Down*:

"At 2,100 feet two large fish, quite three feet over all, lighted up and then became one with the darkness about them, a tantalising glimpse which made me, more than ever, long for bigger and better nets.

"At 2,450 feet a very large, dim, but not indistinct outline came into view for a fraction of a second (and at 2,500 a delicately illumined ctenophore jelly throbbed past). Without warning, the large fish returned and this time I saw its complete, shadow-like contour as it passed through the farthest end of the beam. Twenty feet is the least possible estimate I can give to its full length, and it was deep in proportion.... For the majority of the "size-conscious" human race this Marine Monster would, I suppose, be the supreme sight of the expedition....

"What this great creature was I cannot say."

There can be no doubt that the most astonishing discoveries will be made when the means of catching deep-sea animals are developed.

But let us return to the investigations of the *Vityaz*.

N. L. Zenkevich, a geologist with the expedition on the *Vityaz*, constructed a water-proof camera with a powerful illuminator for deep-sea photography. This camera works automatically, the flash of the electric lamp synchronising with the shutter.

Look at this lucky photograph made by Zenkevich in a tropical zone of the Pacific at a depth of 2,970 metres. It

shows the trace of a large, unknown sea animal. Judging by the shadows, this trace on the sea floor is convex. In all probability it belongs to a very large sea worm feeding on ooze and living in the sea bed. The natural width of the trace is about 10 centimetres. If we assume the ratio between the width and length as averaging 1:12 or 1:15, as in the case of known sea worms, it gives us sufficient grounds for considering that this worm was 1.2-1.5 metres long.

A similar photograph made in the Atlantic at a depth of about 5,000 metres was published some time ago by the American scientist Richard Carrington. The trace in it is similar to the one in Zenkevich's photograph. We can thus draw the conclusion that these worms live both in the Pacific and the Atlantic. However, no scientist or fisherman has yet caught one of these worms or even a part of one with a trawl, drag or other means.

In 1951-56, while studying Far Eastern whales I visited coastal whaling stations on the Kuril Islands, hunted whales in the North-Western part of the Pacific and spoke to many whalers. One day when we watched a large shark, its tall fin sticking out of the water, swimming past our whaling ship, a harpooner named Ivan Skripkin said to me:

"Look, you're a scientist. Can you tell me the name of the animal that we've been seeing for several years running near the Komandorskiye Islands? Almost always it appears in one and the same spot and at one and the same time, usually during the first half of July. The spot where we see it is about 30 miles south-east of the Komandorskiye Islands in the Pacific. When we hunt whales in that region, we see it at least once or twice every year. It's not a whale, of course. It doesn't spout a fountain like a whale and it does not stick its head out of the water. Like this shark, it shows only the hump of its smooth back, which is black and huge, without fins. This great hump rises out of the water, rides a wave and then disappears, leaving an

enormous pancake* as though it were a large sperm whale. We've never come near enough to take a shot at it with a harpoon. We've had a lot of arguments about it, but none of us can say what it is. Is it a fish? It's about ten metres long, you can take my word for it It's a puzzle I can tell you."

I was unable to name the animal for Skripkin. It might have been a giant cuttle-fish, but no giant cuttle-fish is black, that colour being very common among deep-water fish. To this day I cannot answer the harpooner's question.

In 1960, Jacques Piccard, son of the famous Swiss physicist Auguste Piccard, accomplished man's first descent to a depth of 11,000 metres in the Pacific Ocean. When his bathyscaphe touched the ocean floor at this enormous depth he saw a flat silvery fish that was about 30 centimetres long and then a large bright-red shrimp.

Do you know what the pressure is at 11,000 metres? Measure the palm of your hand. It will probably be not more than 70-90 square centimetres. With every ten metres of depth the pressure increases by one atmosphere, in other words, by one kilo per square centimetre. Consequently, at 11,000 metres the pressure per square centimetre will be 1,100 kilos, while on your palm, if it measures 90 square centimetres, it will be nearly 100,000 kilos.

The flat fish seen by Piccard was probably at least 10 centimetres wide, which makes its surface not less than 300 square centimetres. Consequently, the pressure acting on it added up to the fantastic magnitude of 330,000 kilos. In spite of that, the fish swam swiftly.

The Piccard fish and shrimp have so far been seen by only one man. They are not known to science.

Do we know everything about the earth's land fauna? In our age of aircraft the entire land area of the globe has

* "Pancakes" are the name whalers give to the trace left on the surface of the sea by a whale when it dives. A large smooth spot with clear-cut edges forms and, at the same time, water rises giving the effect of a small whirl-pool.—*Auth.*

been explored and photographed from the air. No unknown islands are left in the ocean. Few islands are uninhabited. In short, the Earth's land area has been investigated much more thoroughly than the ocean.

Nevertheless, there are places where the most astonishing discoveries are possible. The okapi, a large ungulate animal, was discovered in the deep forests of the Congo in 1900. The largest of the known bulls, the Savel bull, was discovered in the jungles of Cambodia as late as the thirties. The story of this discovery is told by the French zoologist Bernard Heuwelmans in his widely known book *On the Trail of Unknown Animals*, in which he also speaks of a ten-metre-long monster, a descendant of the fossil iguanodon or ceratosaurus, described as a dragon by hunters who claimed to have seen it. Many tales and legends about this dragon became current in the twenties. Eye-witness accounts were published by many scientists, including the zoologist Willy Ley and the archaeologist Koldewey. As recently as 1962, Professor Georges Mounin of the University of Aix-en-Provence, France, wrote: "...it is quite possible that a variety of the iguanodon or ceratosaurus is extant in the basin of the Congo to this day." Large areas of the Congo basin still await detailed scientific exploration.

In the Soviet Union, too, there are extensive regions where little or no exploration at all has been conducted. One of them is the huge, sparsely populated Sordongnokh Plateau situated near the Pole of Cold in the Oimyakon highlands of East Siberia. It is equal in size to Belgium.

According to geologists, in the Tertiary period this region was relatively low-lying, gradually sloping eastward to the shore of the Sea of Okhotsk. However, mountain-building processes cut this lowland off from the Sea of Okhotsk, raising it to nearly 1,000 metres above sea level. The rivers that flowed eastward and drained into the Sea

of Okhotsk turned to the west, north-west and north. Some of the small rivers were dammed up by landslides and these formed a system of interconnected lakes.

In July 1953 the Sordongnokh Plateau was surveyed by a team of geologists led by V. A. Tverdokhlebov. It was a bright, sunny day when Tverdokhlebov and a young companion named Boris Bashkatov approached Lake Vorota. There was practically no wind. About 300 metres away from the shore the two men saw something shining in the sun. At first they thought it was an empty petrol drum, but looking closer they saw that it was moving. It was swimming rapidly towards the shore to the spot where they were standing. Climbing a cliff the geologists continued to watch the animal It was near enough for them to get a good look at the part of it that was above the water. The head was about two metres wide. The eyes were widely spaced. The dark-grey, massive body was roughly ten metres long. There were two light spots on each side of the head. On the back was a narrow, half-metre-long fin. It moved in spurts, rising above the water and then disappearing. It stopped about a hundred metres away from the shore, thrashing the water and raising cascades of spray. Then it dived and did not appear again although the watchers waited for half an hour.

The nearest settlement was 120 kilometres from the lake. The lakes in the Sordongnokh Plateau, particularly Lake Labynkyr, which is the biggest of them (about 15 kilometres long and nearly 60 metres deep) have a bad reputation. The local hunters and fishermen are convinced that a monster, which they call the devil, lives in Lake Labynkyr. It had carried away many hunters' dogs sent to retrieve ducks in the lake. On one occasion it had chased the raft of a fisherman, who said it had enormous jaws and a dark-grey body. In short, many of the local inhabitants have seen it.

There is no doubt that the lakes in the Sordongnokh Plateau are inhabited by some strange large animals. Possibly these fish or mammals are left-overs from the Tertiary

period. This is not a fantastic hypothesis. Suffice it to recall the latimeria. I should like to emphasise that no zoologist or botanist has yet been to the Sordongnokh Plateau, and hunters and fishermen rarely visit it. Man has not influenced Nature there, thanks to which a natural preserve has taken shape.

Tverdokhlebov wrote to me that in one of the lakes his men caught a fish "that does not resemble any of the species known locally. It had orange flesh. . . . We came across vast fields (swamps) overgrown with long red moss. It's probably Tertiary sphagnum. I have never seen moss of this kind anywhere else in the North."

These observations are extremely interesting. Indeed, if there are remains of ancient fauna and flora in the Sordongnokh Plateau, we can expect fascinating discoveries there.

Here is another striking example showing how much ground there is yet to be covered by exploration, this time in Central Asia.

Professor B. F. Porshnev, who visited the deep Lake Sary-Chelek in the Chatkal spurs of the Tien-Shan in September 1959, related:

"Lake Sary-Chelek is about eight kilometres long and was probably formed in the Quaternary period. Most of it is surrounded by sheer cliffs, and there are bays and beaches along the few relatively flat stretches of shore. A fish called marinka began to be caught there on a large scale only two or three years ago. There is no permanent settlement. Sheep graze on the shore and there are a few apiaries. I learned from the local population that in the lake there is a strange animal that the fishermen have seen frequently in the past two years. They call it a snake. I am told it has a silvery body and that it is almost as fast as a motor-boat. On many occasions, hunters have seen it swim right across the lake and disappear at the very shore. They asked me to write about it to zoologists in Moscow and ask them to come to Lake Sary-Chelek.

"I did not attach much importance to these stories and soon forgot them.

"Several days later five of us took a motor-boat and sailed in the lake, thinking to shoot some ducks. It was a cloudless day and there was no wind. On a clear day the air in the mountains is especially transparent, giving wonderful visibility. When we went ashore on a beach, we suddenly saw something that looked like a log rapidly swimming across the lake. It was about 40 centimetres above the water, shining in the sun as though it were painted with silver. It was about half a kilometre away from us. It abruptly changed direction and we saw its tail, which was about a metre and a half long or four times as long as the part above water.

"The five of us rushed to our boat. We quickly started the motor and headed for this moving object. None of us doubted that it was a living creature and, possibly, the snake mentioned by the local hunters. After swimming almost to the shore of the bay, the animal dived and disappeared. We circled over the spot for a long time in the hope of seeing it but it did not show itself again."

Not being a zoologist Professor Porshnev, who is a historian, was unable to determine even approximately what this animal was and to what group it belonged. He did not want to advance any theory. The only thing that he and his companions had no doubts about was that it was a fast-swimming creature, which changed direction as it swam. One of the professor's companions was a physicist, so he naturally could not determine what this animal was either.

On the evidence of many puzzling observations, we can safely surmise that there are large unknown invertebrates, fish, amphibians and even mammals in the world. Some of the places they inhabit are today inaccessible to man. However, technology is developing at such a rapid rate that we have grounds for hoping to be able to catch or photograph them and add them to the list of known inhabitants of our planet.

In the summer of 1959 Alexander Ryumin, a biologist, led a small expedition to the huge Kapova Cave in the South Urals with the objective of finding traces of Stone Age settlements and, if possible, drawings made by primitive man

The task was a formidable one The cave with its countless passages, grottos, crevices and galleries had been inspected by many people since its discovery nearly two hundred years ago. But nobody had seen drawings on the wall

In the light of their torches, the investigators examined virtually every inch of the walls, peering at the slimy outcrops in it, at the multitude of cracks and scratches, hoping to see something they could accept as man-drawn

The most incredible thing is that they found what they looked for

More than forty Paleolithic drawings have been identified on both levels in the Kapova Cave

Just like the La Moutte Cave in France, where first paintings and then sculptures were found, Kapova Cave may prove to contain engravings and sculptures This, probably, also concerns other caves in the Urals, Siberia and the Altai Mountains, for it has now been established that as seats of culture the Urals are possibly as old as or even older than the Pyrenees

Drawings of monsters with the head and arms of a man and the body of an animal were found in 1962 The search for prehistoric paintings continues

Summer and winter, parties of scientists go deep into the caves where, crawling along the labyrinths of passages and climbing steep clay "pipes" and deep crevices, they search for Paleolithic paintings on the cold wet walls

As in the caves in the Pyrenees and South France, they are finding examples of the art of people who lived in prehistoric times.

ANATOLY VARSHAVSKY

(from *"Treasure Caves"*)

Alexander Ryumin

AMID ETERNAL DARKNESS

A fascinating land lay before us. Colourless moss and grass grew beneath the stone sky, and hymenopterous birds flew noiselessly in the air. Salamanders and eyeless fish swam in the lakes and rivers. The architecture of the palaces was fantastic.

This was the world of caves. The seventh continent. Much less is known about it than about the Antarctic. A new science called speleology or the systematic exploration of caves has emerged some years ago. Speleologists are the men who are storming the enigmatical continent of eternal night.

Our small team of amateur speleologists was exploring caves in the South Urals, which is only a small part of this continent of caves. For the third year in succession I spent my holiday in the famous Kapova Cave. Our choice was not accidental. Several years ago.... But before giving an account of our search it is necessary to make a brief excursion into the remote past.

At the dawn of history, when the window on civilisation was being hewn with a stone axe, the first people settled in caves, which protected

them from the stern climate and wild beasts. On the walls of their gloomy dwellings, they left us samples of their art, whose realism and flights of fantasy leave us speechless with delight.

Until recently, cave paintings were found only in South-Western Europe—in the grottos of the Pyrenees—and in North Africa.

During the many years that I spent studying fossil fauna in the South Urals, I gradually came to the conclusion that the caves in these most ancient of European mountains might have traces of prehistoric paintings. Indeed, when the central zone of Europe lay under a sheet of ice nearly a kilometre thick, the South Urals was about 1,000 kilometres away from the edge of the glacier. This region had a warm climate and the limestone caves were convenient as dwellings. Was it not therefore a permanent place of settlement by primitive man? I could not agree with the opinion of some scientists who believe that the Urals were a sort of a thoroughway for prehistoric man during his migration from Europe to Asia. Cave paintings in the Urals irrefutably prove that this region had a settled culture that was perhaps even older than the culture in the Pyrenees. That sheds a lot of light on many questions concerning where prehistoric man lived. In the search for these paintings I was accompanied by a group of students from institutes in Moscow and the Urals. These notes describe our cave adventures.

* * *

An enormous arch reaching to a height of 20 metres led to the first grotto. There was a frozen waterfall over a lake near the entrance. A little to the right of the waterfall was a passage leading to an unknown world. Forbidding cliffs surrounded us. We tried to examine the cave scrupulously. Speleologists had been in it before us, but their search had not been methodical and they had gone away empty-handed.

Our small torches cut through the darkness around us. Crystal icicles flashed overhead, and from the floor two-metre-long stalagmites stretched towards them. It was a dazzlingly beautiful sight. In one of the grottos a stone waterfall reached almost to the top of the vault. The play of light created the illusion of falling water. We made our way up along the "streams" of this waterfall as though they were a staircase. White crystal moss crunched underfoot. Suddenly all of us stopped in our tracks: our flickering torches showed us a tiny stone flower, the like of which none of us had ever seen before. We made a wall of stones around it so that this miracle of Nature would not be accidentally trampled.

For hour after hour we inspected the walls, but found nothing except protruding stones, cracks and scratches. Exhaustion and the silence made our ears ring. Now and then a drop of water would fall on the stone floor or a bat would squeal. Then at last, the ray of one of the torches fell on an indistinct picture. We gazed fixedly at it. There could be no mistake about it. The picture showed a large head, and powerful jaws with long fangs. In the course of tens of thousands of years the paint had turned brown. This together with the streaks left on the wall by water made the painting hardly distinguishable. But there could be no doubt that we had at last discovered a painting made by prehistoric Urals artists.

We continued our search for several more days, negotiating the narrow passages and the steep clayey "pipes". Intoxicated by our first success, we carefully examined other grottos, finding a small picture gallery that included a splendid, well-preserved drawing of a wild horse that had become extinct thousands of years ago. The painting was made with ochre, a favourite medium of prehistoric artists. Its style is that of the Aurignac-Solutrean school of Paleolithic painting (40,000-50,000 years ago). Some of the paintings might belong to later "schools".

The news that paintings had been found called forth contradictory opinions. Some scientists doubted that they were paintings at all. However, all of them agreed that the Kapova Cave was of considerable interest to science. The Academy of Sciences began fitting out an expedition. In the following year, before the results of the Academy's expedition were published, our team of enthusiasts returned to the Urals to continue our search.

* * *

My companions turned off into the side passages in the cave. I pushed ahead through the main passage, deciding to reach the underground lake that I had heard so much about from people living in the vicinity. My torch shone dimly and I groped my way along the cold wet walls. Now and then I had to crawl. Then at last a narrow hole brought me to the lake. Its black surface looked greasy as though oil had flooded the cave. If only I had a rubber boat! There was nothing I could do except retrace my steps. My companions were probably waiting for me. I crawled back for what seemed to me about twenty metres before I realised that something was wrong. The passage I had come by was shorter. Had I lost my way in some labyrinth? I raised myself on my elbows—my arms slipped along the mud and I began to slide down the sloping floor My torch hit a stone and went out. I continued sliding until finally I caught hold of a protruding rock. In the inky blackness I could not tell where I was. What if the edge of an underground abyss was only a few inches away from me? I had to do something about the torch. I took it to pieces and wiped it dry with my shirt. That made it work again. I looked at my watch: only seven minutes had passed since I left the shore, but to me it seemed that I had spent at least an hour in this labyrinth. I remember having experienced the same feeling when in the Kara-Kum

Desert a metre-long viper seemed to be a kilometre long as with sinking heart I watched it crawl over my bare foot.

With the aid of the torch I found my way to the grotto where my companions were waiting for me. Feeling tired I sat down and switched off the torch, letting the darkness and silence engulf me. They were the masters here. Time did not exist in this underground world. The passage of hundreds of thousands of years had done nothing to change these grottos and galleries. I pictured to myself what it was like for prehistoric people in these dark, cold labyrinths which they had not yet won completely from beasts of prey. Yet this was where an ancient art was born. What inexhaustible creative strength there is in man!

These notes will probably make a trained speleologist smile. But at that time we were just getting into the swing of underground exploration and, besides, we were interested in the scientific aspect of it. Our enthusiasm made up for our lack of training. That enabled us to overcome the difficulties that we encountered.

* * *

I recognised the grotto where in the previous year I came across a present-day inhabitant of the cave. I was alone in a wide gallery and had turned off my torch to save the battery. Suddenly above the tinkle of dripping water it seemed to me that I heard strange groans. To make sure that the acoustics in the cave were not playing tricks with my hearing I turned on my torch. A brown bear was moving towards me. It was only about ten paces away. I backed away and, obeying some instinct, aimed the beam of my torch at the animal's shaggy face. With a roar it turned and fled. I found pieces of its fur on the sharp stones.

And now, remembering that encounter, I carefully probed the darkness with my torch, although I knew that bears do not enter caves in summer.

* * *

We were in a small dry chamber. In the light of a torch we saw some brown spots on the wall. Was it red ochre? I turned the torch off and on several times so that if there were any harmony in the arrangement of the spots I would see it quicker. Indeed, before us was the silhouette of an unknown animal.

"Do you think it's a horse?" asked one of the students from Moscow.

"I'd say it's a mammoth," another replied.

While they argued I took several photographs. These and a detailed examination would show whether it was a genuine Paleolithic drawing or simply an optical illusion. My companions were disappointed when I did not give them a definite answer. I understood them. I would very much have liked to say: "Yes, we've found another Stone Age painting." But science holds no brief for hasty conclusions. This is all the more true of speleology, which has neither tried methods nor sufficient practical experience. We were pioneering a new field and had to be strict with ourselves.

"Never mind," I said. "The important thing is that there are plenty of cave paintings waiting to be found. We'll continue our search."

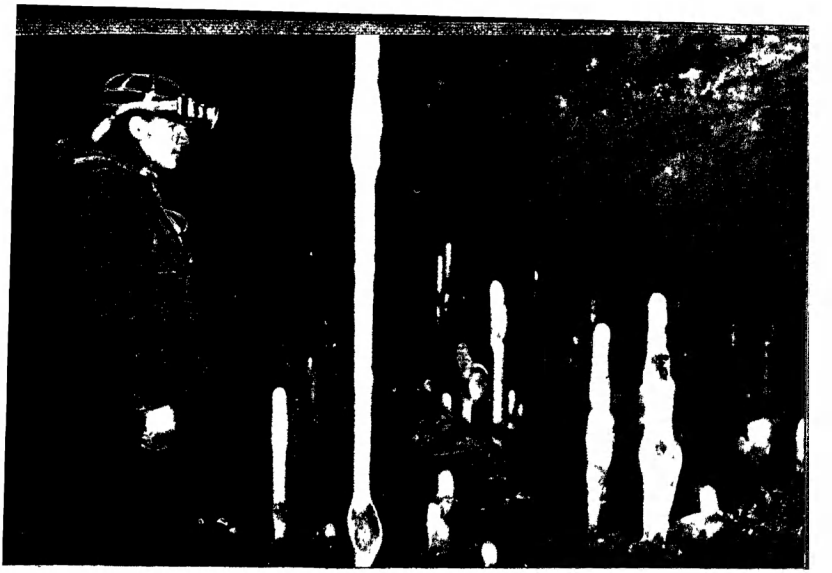
Suddenly somebody cried out:

"This way, quick!"

I ran forward and lit the wall up with my torch. A large spider flashed in the beam and disappeared behind a stone. What a pity we did not catch it. There are very few insects here: the caves are inhabited by several species of unpigmented wood lice, myriapods and filiform glow-worms. But nobody had seen spiders in them. It would have been a surprise for specialists.

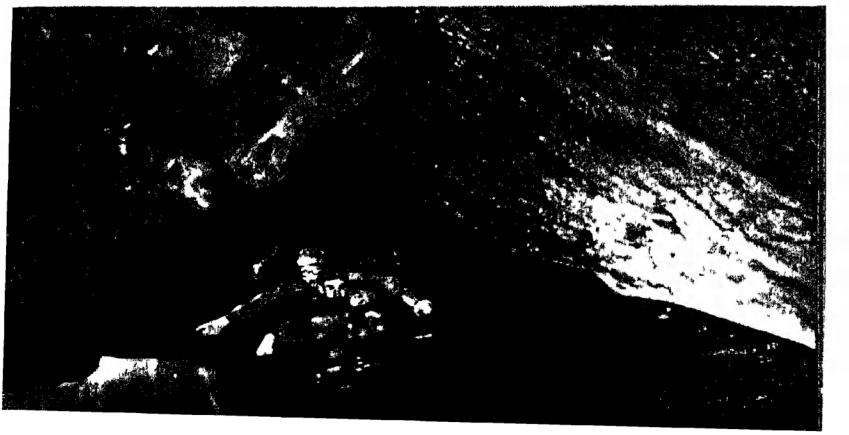
* * *

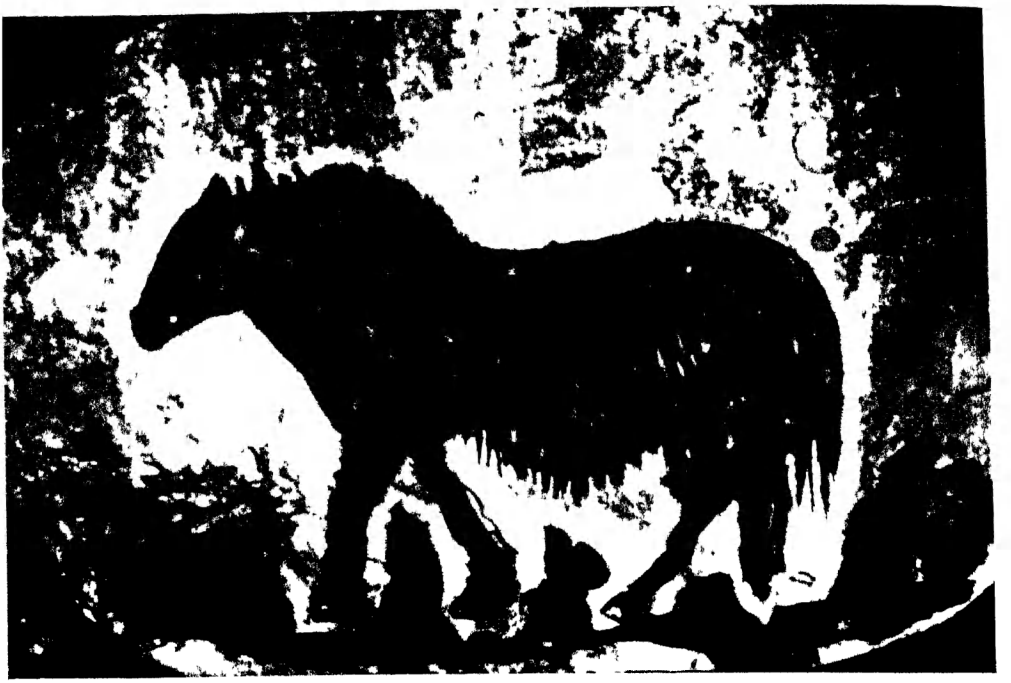
With ropes and the rest of our scanty gear we made for the belfry, the name we gave to a high cupola-like chamber,



Stalagmites in front of the entrance to a cave

Subterranean Ritsa River





A wild steppe horse

Mammoth

This cave drawing of a fossil cave lion was discovered in 1962 in Kapova Cave

whose upper part had a passage to the second tier. We crawled, clinging to the stones, but the grey sloping walls were slippery, and we had the sensation of trying to climb out of a glass jar. We kept sliding down to the bottom and making new tries, until at last we scrambled on to a small platform.

It was only about 12 paces to the entrance but we had no more rope. We could not risk climbing a sheer rock without taking precautions. The belfry had us beat and we had no alternative but to turn back.

The next morning we returned with long poles with which we hoped to get to the top of the slippery rock. They were the "latest word" in speleological technique. But could we help it when there was no other gear? With the help of the poles we got to the second tier. I had been there in the previous year, when the belfry had been dry and it had been quite easy to climb to the top.

The resonant grottos of the upper tier were all around us. We busied ourselves taking flashlight photographs.

All of us turned off our torches when we had to put a new film into the camera. No dark room is as dark as these caves. Then suddenly we saw a light. Soft and hardly perceptible it flowed from the walls. The stones shone.

It was breath-taking to see this light. Greenish-yellow, it came from the calcite stalactites and stalagmites. Even the ceiling glowed as though a distant dawn were breaking over the earth.

The calcite evidently contains an admixture that causes this mysterious light to appear after it is illumined by a flash-bulb. This phenomenon was observed in the Crimea by the speleologist V. Ilyukhin of Moscow.

. . . The stars were twinkling over our camp. We drank fragrant tea at the entrance to Kapova Cave.

We had covered quite a lot of ground in the cave. It was safe to suppose that the South Urals seat of Paleolithic culture embraced the mountainous regions along the

Belaya, Yurisan and Ural rivers. Kapova Cave was probably the centre of this seat, and that accounted for the paintings in it. However, much of the cave remained to be explored.

In my pocket I had a letter forwarded to me by the editors of the magazine *Vokrug Sveta.* It was written by amateur speleologists, who claimed they had found a new sector of the cave, and wondered if it had paintings. The entrance, they said, was near the underground lake. We decided to investigate.

We spent a few days exploring the environs of the lake, but there was not a single crack in the walls. All we found were two crevice-like passages, but they were too narrow. In fact, they could be described as mouse-traps, being only about half a metre high. All the same we had a go at them.

I climbed into one crevice and Vira, an engineer from Sverdlovsk and our most indefatigable pathfinder, into the other.

After crawling for half an hour I felt dog-tired and turned back, angry that after all this trouble my only reward was a blank wall.

Vira had not yet returned. I quickly climbed into the hole into which he had disappeared, feeling responsible for his safety. But nothing had happened to him. With a beaming smile he was waiting for me in a large cave to which the hole had brought him.

The amateur speleologists who sent the letter had not been wrong. New galleries began at this cave. A marvellous scene lay before us. Pearly stalactites gleamed on the white vault of the cave. A blue, icy, winding channel on the floor held a river of stone. On the black floor there were stretches of shining calcites.

It was 5°C in the cave, but the dazzlingly frosty landscape gave the impression that it was the middle of a snowy winter.

"This beats the treasures of Alhambra, of Scheherazade!" Vira exclaimed with breathless delight.

Yellow, white and dark purple stars glimmered at our feet. It seemed as though fabulous wealth had been strewn on the ground by some generous hand. These star clusters were druses, lovely cave flowers. Here lying amid fluffy, needle-like overgrowths, there forming stalks, roses and rhombs, the tiny stars sparkled in the light of our torches. I had not seen such well-preserved stalactite galleries in the Crimea, the Caucasus or the Urals.

This section of the cave was only in the early stage of stalactite formation. The stalactites hanging from the ceiling were small and water was dripping down them. Small calcite growths, future stalagmites, were rising from the floor towards them. This was evidence of the gallery's "youth". There was nothing in it except minerals. We could not expect to see paintings because it was unlikely that man had penetrated into it.

A hole showed at the far corner of one of the grottos. We bent carefully over the edge.

The slippery clayey floor sloped at a steep angle. The bottom was too far down for the beam of our torches to reach it. Rocks were perched precariously along the edge, ready to tear away at the least disturbance. The rumbling of a river could be heard in the darkness.

"It's an escalator," the ever cheerful Vira joked. "Sit on it and it'll take you straight to a sabre-tooth tiger."

We had a short conference. Below us was an unexplored tier of grottos. We could not resist the temptation.

* * *

I stepped on the "slippery way" first and Vira followed. The rest of the party remained behind in case anything happened.

The angle of the slope was about 40° and it was like sliding down a chute. We descended with bated breath,

passing balancing rocks, each weighing at least a ton. We stopped every half metre to drive a stake into the mud. These stakes allowed us to by-pass the rocks and to have something to hold on to when our feet dangled over a void.

During one of these stops a rock hurtled past me. Instinctively I jumped away. Losing my footing I fell into the void as far as my rope let me.

"Are you all right?" I heard Vira cry anxiously.

The reply must have been so incoherent that my friend lowered himself and felt me over.

"No bones broken," he declared with relief. "It was my fault the rock fell."

Lighting our way with our torches, we finally saw the bottom. Vira clung to the wall, to ensure my safety.

On the floor I saw a turbulent river flowing beneath the vaults of giant halls. Tearing across the chaotically piled rocks, it calmed down as it flowed into the lake.

I found myself standing on a splendid sandy beach. The lake receded into the darkness.

"Eureka. A cave resort," I shouted to Vira.

My friend soon joined me, gazing eagerly at the lake and standing stock-still, enthralled by the majesty of this untouched subterranean world. We made a small pyramid of stones to mark that this part of the cave had been visited.

Because we had no boat we could examine only the shore. Steep ridges stood like phantoms on all sides of us.

Some days later we returned to the lake, bringing a rubber boat with us. The lake did not prove to be as big as we had thought. Some twenty metres from the shore it flowed beneath low vaults. We squeezed into the narrow passage and reached the upper part of the river.

We did not find any ancient drawings on this tier of the cave.

* * *

... Exploring the seventh continent is fascinating work, and I am proud of my courageous friends, who are opening the casket of underground mysteries.

With gratitude I think of the brothers Nikolai and Mikhail Zheludkov, Vasily Guryanov and the forester Alexander Yevgrafov, all of whom are from the Urals, and of my numerous friends from among amateur speleologists in Moscow, Leningrad, Sverdlovsk, Magnitogorsk and Ufa; and also from among the raftsmen on the Belaya River.

In Kapova Cave we discovered several Paleolithic drawings. That was a promising beginning.

The upper tier of the cave, visited more than 150 years ago by Academician Lepekhin, remains unexplored.

The Academy's expedition headed by O. N. Bader has confirmed that there are Paleolithic paintings in the South Urals. That has struck a blow at the theories claiming that Stone Age cave art is the monopoly of Western Europe I think I can safely say that science will soon learn of new galleries of cave painting in the Urals. Nobody knows what secrets are concealed in the caves of Siberia, the Altai Mountains and Central Asia. It is quite possible that paintings will be found in them. After all, we do know that the world's most ancient civilisations arose in those areas. The finds in Kapova Cave are a foretoken of exciting discoveries in the future.

Recorded by *Y. Guryev* and *L. Tsesarkin*

Rudolph Bershadsky

ATLANTIS

An avalanche of fabulous discoveries, started after the war and continuing to this day, is enriching archaeology.

A brief review of some of the most outstanding discoveries takes us first to Palestine with its biblical landscape: the warm-grey, rippling Dead Sea which even birds avoid; the dark-brown shadows cast by the monotonously bare hills; the sombre colours of the sunset; piteous sheep huddling together in flocks; the cold nights in the desert, where the sands ripple in the wind. It seemed as though time had stopped in this remote corner of the world.

Yet these places once blazed in world-wide glory. This was where stood the great Temple of Jerusalem, which, if we are to believe contemporaries, had no equal in the world. This was where Jesus Christ, son of God, lived among men to the day of his crucification, together with robbers, by the Romans, and of his resurrection. This is the homeland of other biblical heroes, who are revered to this day by Christians of all denominations.

No other place in the world attracted people so persistently over such a long period. Mil-

lions of people swarmed to Palestine: to recover the Holy Land from the infidels as the eight crusades of the Middle Ages attempted to do; then, after the failure of these locusts in knight's armour, to pay homage to this grave as pilgrims and bring back a handful of earth.

Nothing else of interest remained in the Holy Land. That, at least, was the view of archaeologists, who regarded Palestine as "barren soil" not worth any attempt to find unknown relics and, least of all, unknown ancient writings.

In the spring of 1947 a Bedouin shepherd named Mohammed Diba found that a little black lamb was missing from his emaciated flock. Had the flock been large, the loss would have passed unnoticed (and science would have missed a valuable prize). Luckily for science, Mohammed Diba's flock was small He knew every sheep in it, particularly that frivolous lamb. It was in the habit of wandering away from the flock and needed watching.

Mohammed searched for it in five gullies, not missing any of the caves. His determination to find the lamb took him to the caves along the Ain-Feshkha stream. Caves was too loud a name for them, because they were really no bigger than cracks. But Mohammed conducted a meticulous search.

In this way he found himself in a cave now known to science as Ain-Feshkha I. Instead of his black lamb he found ancient manuscripts of the Bible and other priceless scrolls written some 2,000 years ago. The crack proved to be a passage to a cave. It was a small, low cave, only two metres wide and about eight metres long, but it made a perfect hiding place.

Mohammed did not see the scrolls at once. Little light penetrated through the narrow passage. However, it was enough to let him see a number of large, wide-necked jars. In them were scrolls tied with flimsy flaxen cloth. The cloth disintegrated into dust the moment he touched it, but happily nothing happened to the scrolls, which Mohammed carefully pulled out of the jars.

Made of hide, they were covered with writing.

More than a thousand books have been written about the scrolls found by the Bedouin shepherd on the shore of the Dead Sea and also about the manuscripts that were discovered later in the same area by other shepherds. The oldest Hebrew manuscripts of the Bible dated from the tenth century. Now science had manuscripts that were a thousand years older.

The caves yielded more than manuscripts of the Bible. In one of the jars lay a scroll with the rules of a religious community. These manuscripts were evidently hidden during the Judean-Roman war. The rules tell us of the life of a first-century A.D. religious community, of its laws, and of its social stratification at a time when a new religion, Christianity, emerged. The rise of new religions has always been a period of radical social upheavals. New religions, mystically, of course, mirror these upheavals. The Christian religion came into being when the declining Roman Empire was unable to resolve the social conflicts of a slave-owning society. From this point of view, the rules of the religious community are especially valuable. Moreover, the finds included a volume of lyrical writings and other extremely interesting materials.

Thus, Palestine proved to be not altogether barren of ancient writings. Archaeologists, who followed up Mohammed Diba's discovery found other manuscripts, including three copper scrolls. They had to be unfolded before they could be read. This was a very complicated operation. The scrolls were carefully packed and sent to the Technological College in Manchester, Britain, where they were opened by Professor H. B. Baker and partially deciphered by Professor Allegro of Manchester University. To this day none of them have been read in full.

In 1952, another cave was found near the Dead Sea. All the facts indicate that it was probably used as a

headquarters by the partisans of Bar Kokhbar, Hebrew leader of an insurrection against Roman invaders. In it were dispatches addressed to Bar Kokhbar and his own letters to various military leaders, and all sorts of civil documents, including a marriage contract and a promissory note, which (to the delight of scientists) was dated. Other finds are coming to light.

• Before scientists could recover from the stunning discovery of the Bedouin shepherd in Palestine, the world was stirred by a new sensation. In 1948, in the ruins of the Toprak-Kala fortress in the Kyzyl-Kum Desert of Central Asia, a Soviet expedition led by Professor Tolstov discovered the first documents written in the language of ancient Khoresm. Yet another long-forgotten culture of ancient Khoresm, that seemed to have been buried for ever in the sands of the Kyzyl-Kum many hundreds of years ago, became known to man. It was found that mankind owes modern algebra to the scientists of Khoresm. We now know that a mighty civilisation flourished in this desert. Step by step we learned how this civilisation developed and what a deep imprint it made on the culture and life of neighbouring countries.

Once again it was a Soviet expedition led by Professor M. Y. Masson that made the next major archaeological discovery.

The mighty Parthian Kingdom arose in the East in the third century B.C. Its cavalry struck fear into the legions of Rome and its frontiers embraced Syria, North India, Armenia and Persia. It existed for nearly five centuries and then crumbled when the enslaved Persians rebelled.

The succeeding generations gleaned their knowledge about Parthia only from Greek and Roman sources, which were scanty, fragmentary and sometimes obviously falsified. No Parthian writings were extant.

In 1948 a Turkmenian collective-farm woman found a potsherd with an inscription written in a strange language.

Unable to read the letters she took it to archaeologists excavating the Parthian capital of Nisa near Ashkhabad. The scientists identified the letters as Parthian.

Excavations were immediately begun in the spot where the potsherd was found. Within a year these excavations yielded six other potsherds and five years later an archive of Parthian clay documents was discovered in Old Nisa. They were read by the Dyakonov brothers and V. Lifshits. Today there are nearly 2,000 of these ostracons, which tell some of the story of Parthia in its own language.

Three years later, in 1951, yet another momentous discovery was made at the other end of the Soviet Union—in Novgorod. Intact letters scratched by ordinary people on birch-bark were found in the wet soil of Novgorod by Professor Artsikhovsky's expedition. These birch-bark scrolls are nearly 1,000 years old.

Prior to this discovery it was believed that illiteracy and ignorance had reigned supreme in Ancient Rus. Not a single piece of writing by ordinary people was found in any of the towns of Ancient Rus, and this led scholars to the conclusion that literacy was the privilege of the nobility and the church, who were the only class that could afford parchment Historians believed that no other writing material existed in those days.

The Novgorod birch-bark scrolls now make it clear that the reason historians could not find any of them in state archives was that nobody bothered to keep them as they were not regarded as having any value.

Hundreds of birch-bark scrolls have been found in Novgorod. They include letters from peasants, artisans and other ordinary people, school notes by students, and notes by merchants and shop-assistants, thus showing that prior to the Tatar invasion literacy was widespread in Rus.

In the year 1952 archaeologists focussed their attention on South America, where the Peruvian scientist Daniel

Ruzo was climbing to the Marcahausi Plateau in the Western Cordilleras to check the truth of a legend, which, recorded during the conquest of Peru by Spain, stated that in one of the mountain plateaus the Conquistadors saw gigantic stone figures of people and animals. Legends of a deity turning to stone men and beasts who committed offences are current throughout the world. It may have seemed absurd that a scientist should want to find out if there was any truth in this myth. However, many of the hunts scientists engage in seem to be wild goose chases until suddenly the uninitiated wake up to discover unprecedented results.

When Daniel Ruzo finally reached the Marcahausi Plateau through the only pass existing in the mountains he at once saw that this pass was made by men, who were skilled in the uses of stone. They built a road to the plateau, and the wall along this road had embrasures from which rocks could be hurled at any enemy trying to enter the plateau. Moreover, there were observation posts and small forts overlooking the road.

But even more spectacular discoveries awaited Ruzo in the plateau itself. When he got there he was astounded to find twelve artificial storage lakes, a large system of irrigation canals, some of which even led underground, two well-preserved dams, and tombstones carved to represent rabbits, rats, fish and toads. This plateau was inhabited by people with a high culture, and other peoples lived here after them. There were tombstones erected by the Quechuas (a once numerous people living in South America to this day), the Incas and their predecessors, the Huancayas. Ruzo's most remarkable discovery was that of traces of a people who inhabited the plateau long before the Incas and were almost unquestionably linked up with Africa.

An accident helped Ruzo. (As a matter of fact, accidents always help people who keep their eyes and ears open and

do not let anything escape their notice.) While looking through a film that he had taken of figures of animals on a stone slab he saw that there was also a figure of a man.

He could not understand how he had not noticed it before until he realised that when he took the photographs he did not scrutinise the slab carefully because he had done so earlier *under different illumination.* The explanation was that the figure of the man could be seen only at a definite time of the day; the sculptor who made it knew that secret.

Ruzo wasted no time examining all the other slabs and cliffs in the plateau at different times of the day and from different angles. What he saw made him gasp with astonishment. Some of the cliffs had been artistically worked and represented mammoth sculptures: for example a head of a Negro (it was made long before Columbus discovered America, that is to say, long before the first Negro known to historians was brought to the American continent), camels (that likewise were unknown in America), elephants, cows and horses, i.e., animals that were not known to the inhabitants of America when Europeans discovered the New World.

How did the figures of all these animals get to the Marcahausi Plateau? Who were the people who sculptured them and how did they know about them?

Daniel Ruzo's discovery has posed science with a riddle that remains unsolved.

The year 1956 saw the discovery of Spina, a major city of the Etruscans, who had a large influence on the political system and religion of ancient Rome. It was their chief port, which traded not only with states on the Mediterranean but also on the Baltic, and is mentioned by Pliny the Elder and Strabo. The search for Spina went on for many decades without success, and many scholars decided that it existed only in the imagination of Pliny and Strabo.

But the world owed too much to the Etruscans for scientists to turn their backs on the riddles of their history.

First and foremost this concerns the Latin alphabet, which is based on the alphabet developed by the Etruscans. Who were these people? What was their origin? What was their language like? The history of this people could be reconstructed only on the evidence left by them. Unfortunately, although we have at our disposal thousands of Etruscan inscriptions, principally on tombstones, we still cannot say what the language itself was like despite the fact that the alphabet is of West-Grecian origin. "It holds aloof from all the languages studied by modern scholars," says the Soviet academic *World History*. "It differs from the Latin languages" and therefore "save for a small number of words and grammatical forms, which can be regarded as having been correctly interpreted" the Etruscan inscriptions remain an enigma.

Now that an entire Etruscan city has been discovered and excavations have begun in it we may expect that the mysteries surrounding the history of its inhabitants will at last be lifted. The finding of Spina was a heroic feat on the part of Professor Nereo Alfieri. From legends it was known that Spina, pearl of the Etruscan empire, was somewhere in the mouth of the Po on the Adriatic shore. A Greco-Etruscan necropolis was discovered in the Po delta (in the Comacchio marshes) only in 1922.

Excavations were conducted with redoubled energy. Archaeologists worked for thirteen years and found 1,250 burials. But there was no trace of the city itself.

The excavations were stopped in 1935.

But Professor Alfieri did not give up. In 1953, after the Comacchio marshes were drained, he resumed his search for Spina. He did not share the general opinion that the evidence of Pliny and Strabo could not be taken seriously. The excavations had yielded nothing, but that meant only one thing: that they had to be more energetic.

He studied historical geography and determined the places that had fallen below sea level and must have towered above the sea in the days of the Etruscan empire. Then he established what Etruscan settlements existed in these places, basing himself on the law of permanent habitat.

"Wherever it is possible," he wrote subsequently, "man strives to settle where habitations had already existed, even if they have disappeared from the face of the earth. In other words, there must have been Roman and then medieval settlements on the site once occupied by Spina.

"A comparison of archaeological data relating to the Middle Ages brought me round to the conclusion that the parish of Santa Maria in Pada Vetera (i.e, on the 'Old Po'), which was built where a pagan temple once stood, was the most probable site of the city of Spina. Air photographs taken later by Professor Valvassori, showed the outlines of the port district of Spina not more than 300 metres away from where the village of Pievi once stood."

The swamp that thousands of years ago engulfed Spina, whose inhabitants abandoned the city when it was attacked by the Gauls, surrendered its secret only in 1956 to the scientist who courageously endured all failures. Grass grows poorly or not at all along ancient walls, and these bald outlines, particularly when they form the geometric contours of a city, are seen clearly from the air.

Alfieri has already excavated his first pile-dwelling in Spina. Further excavations are now only a matter of time and money. But a lot of money is required because Spina is "soaking wet" and the excavation sites are being continuously flooded despite the fact that the swamp has been drained. Alfieri is forced to fence the sites off with metal shields and keep pumps going uninterruptedly. He has dug up thousands of lovely terra cotta, ceramic and bronze artifacts. Like all other ancient peoples, the Etruscans believed there was a life after death and fitted their dead

out for that life. The burials dug up by Alfieri contained tools, household utensils and ornaments, while child burials had even terra cotta dolls with moving hands and feet.

It is hard to cause a sensation in Paris. But the city was spellbound when an exhibition of paintings was opened in the Marsan Pavilion near the Museum of Decorative Art. The paintings were found in the Sahara by Lieutenant Brenans in 1933 and then copied by the ethnographer Henri Lhote. (I must make a correction in what I have just said: the exhibition was not of the paintings themselves, which are made on rocks, but of reproductions.)

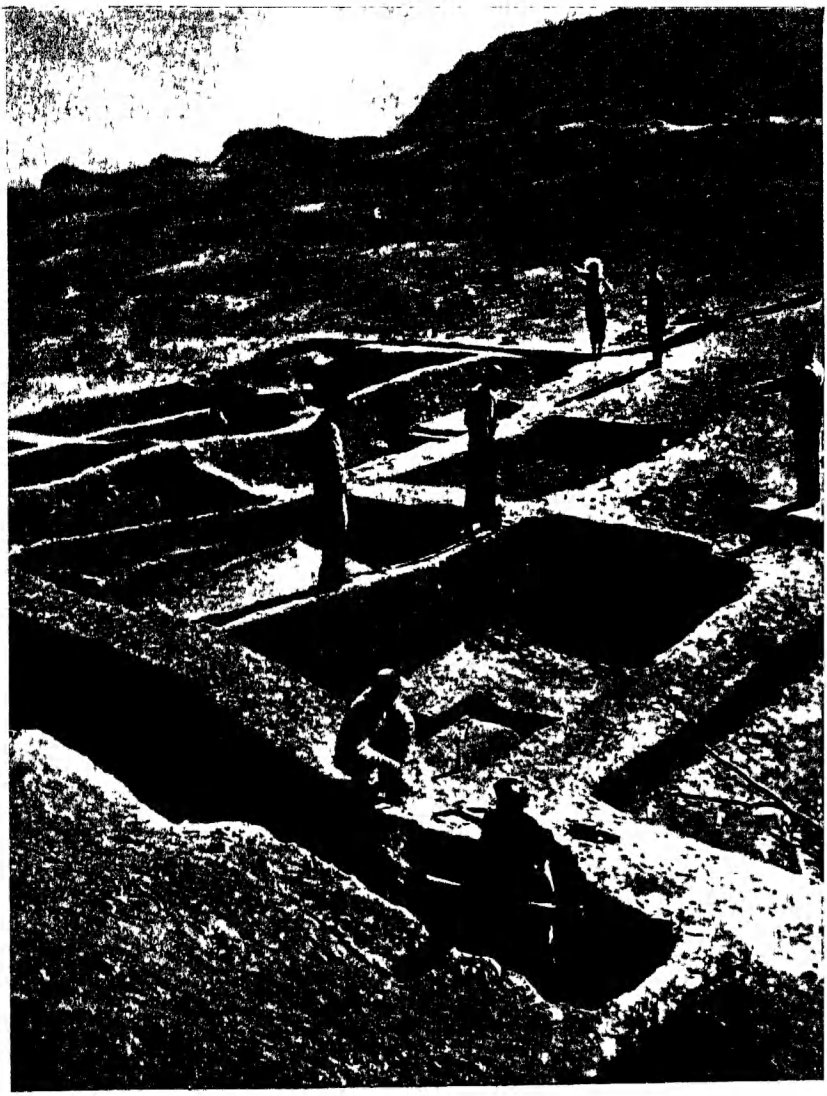
Paris and then the whole world viewed these captivating works of prehistoric art with delight and wonder.

In 1933 a young French lieutenant, much against his will, was stationed in a remote sector of the Sahara and sent on a mission into the heart of the desert. Indeed, he had every reason to rail at his fate. It was 1,500 kilometres to the nearest bath and barber shop. At night the rocks were covered with hoar-frost, while during the day it was so hot it was possible to fry a fish in the sun. No wonder people had never lived in this region—scientists had established that as a fact!

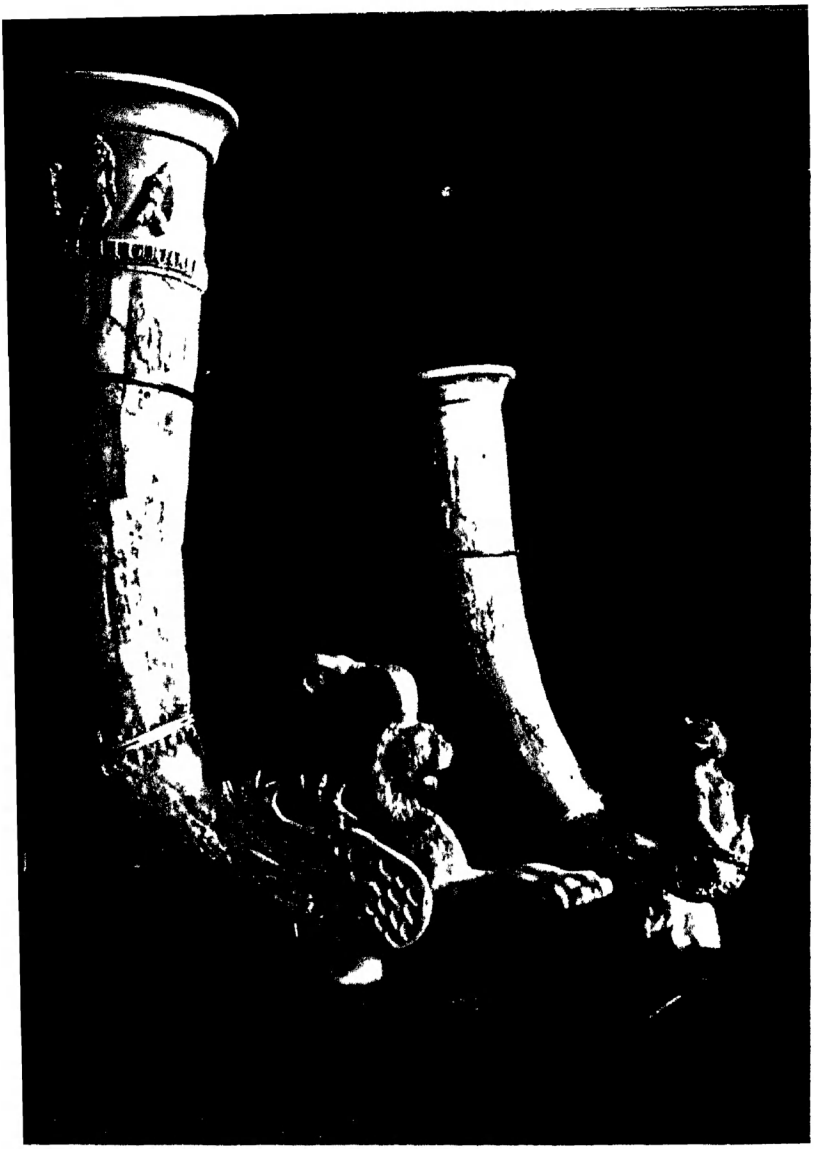
But Lieutenant Brenans was soon to find that the scientists were wrong. And insofar as it happened towards evening, he did not fall asleep until late the next day.

At first he decided that the desert had made him lose his senses. While making ready for the night in a cave he suddenly saw a drawing of a giraffe on the wall. He looked closer. What he imagined was a delusion did not disappear. The drawing showed dimly through a film of hardened dust. Who made it? Brenans did not believe in the supernatural. So it must have been made by a human being. But how did man get here if the desert had never been inhabited?

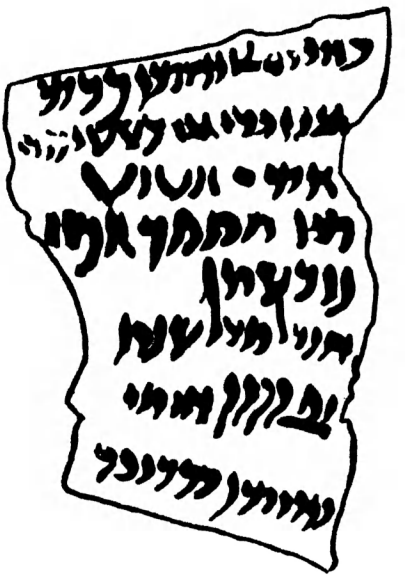
Brenans began scraping the dust off the drawing and was amazed to see that it had been painted with colours.



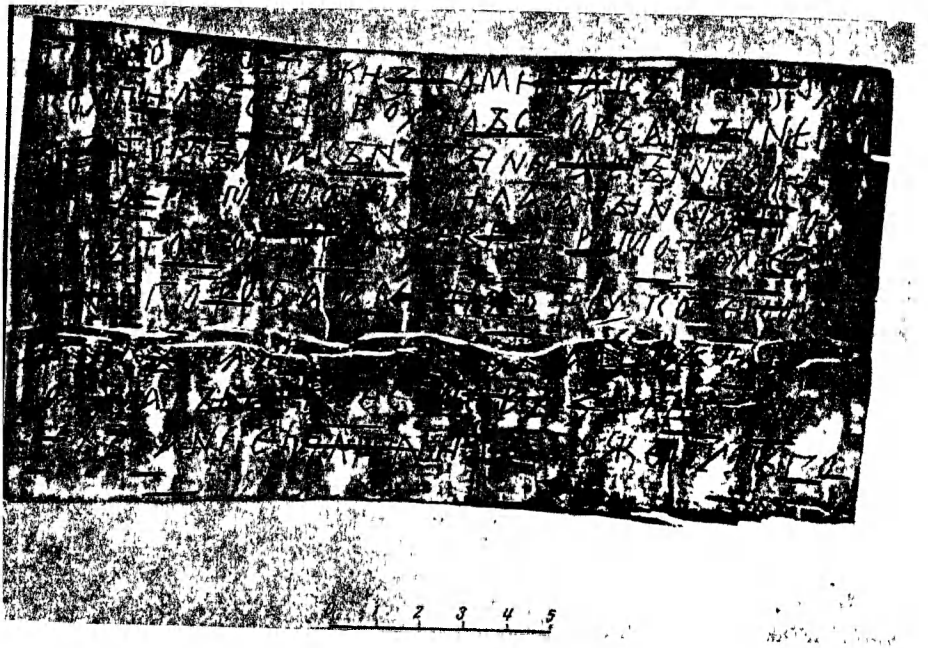
Excavations near Nissa by the Turkmenian archaeological expedition



Vessels found in the Nissa excavations



Ostracons



Novgorod birch-bark scrolls

Before him was a splendid painting obviously made in prehistoric times.

As soon as it was light he inspected the nearby caves and rocks, finding numerous drawings made by people who lived here in a remote age.

He realised that he had stumbled across something important. He could not, of course, explain where the people who lived here came from. But that did not worry him. He had facts and if scholars attempted to contradict them it would only be worse for them.

The lieutenant made sketches of the rock drawings and sent them to Paris, giving the exact location of his find: the Tassili-n-Ajjer Plateau in the Central Sahara, 1,500 kilometres from the nearest bath and barber shop.

Brenans' report was so electrifying that a group of scientists at once set out for the Sahara. They included Professors Gautier, Reygasse and Perret and the young ethnographer Henri Lhote.

Upon their return to France six weeks later the scientists publicly announced that everything Brenans said was true: the widespread belief that the Central Sahara had never been inhabited was wrong. The Tassili-n-Ajjer rock paintings of elephants, rhinoceroses, giraffes, antelopes, hippopotamuses and crocodiles, made 8,000 or 9,000 years ago, irrefutably showed that the Sahara had once been a lush savannah with deep rivers and numerous human habitations. The people who lived in it hunted the animals depicted in the drawings, then domesticated some of them.

Unfortunately the professors referred only to what they had seen themselves. Science required that Brenans' discovery should be made public, that exact copies of the drawings should be made available.

This work was ultimately done by Henri Lhote, who displayed the copies in the Marsan Pavilion in 1957.

He remained in the Sahara after the party of scientists returned home, and aided by Brenans, who obtained his

discharge from the army in order to be able to devote himself to archaeology, spent eighteen months looking for and cleaning paintings. It was hard work: the nearest water source was tens of kilometres away, and they had to labour in icy cold and burning heat.

Then the war interrupted them. When it ended Brenans was no longer among the living and Henri Lhote continued the work alone.

In 1955 the National Research Centre provided Lhote with funds to employ a team of photographers and artists, and in 1957 he brought to Paris 700 square metres of reproductions of the Sahara drawings.

On some of the rocks there were as many as sixteen layers of drawings. This meant that people lived in permanent settlements for thousands of years. Hunting gave way to herding, and pictures appeared of herds of cattle with herders, of battles between tribes over cattle, of new anthropological types. Many of the paintings are obviously ritual and show the change of religions. Lhote does not exaggerate when he says that a treasure-store of the most wonderful prehistoric art in the world has been discovered in the Sahara. One can only add that it is perhaps the richest treasure-store.

It was one of the archaeological sensations of 1957.

The next year brought a discovery that shone like a star of the first magnitude even against the background of what we have already listed. In Jericho the English archaeologist Cathleen Kenyon discovered the ruins of a town that she thinks is 8,000 years old, i.e., 2,000-3,000 years older than the culture of Egypt.

If what Cathleen Kenyon found are the ruins of a town and if they are as old as she believes, it means she has come across the world's most ancient civilisation and that many, very many of the problems of human history will have to be radically revised.

Such are the outstanding archaeological discoveries that have been made in the world since the war. Although it would seem improper to mention inconsequential finds in the same breath, that is exactly what I propose to do. I want to speak of the potsherds that were found some years ago on the site of the ancient city of Panticapaeum, capital of the Bosporan Kingdom, which once occupied the shore along the Kerch Strait and adjoining regions.

In themselves the potsherds were not outstanding. Over the past few decades and even earlier excavations in Panticapaeum yielded many thousands of virtually similar potsherds and also many splendidly preserved artifacts. Regarded in that light the potsherds found in 1958 were not rare.

But there must be a reason for mentioning them together with the most outstanding archaeological discoveries of recent years. The reason lies in *where* they were found. They were obtained not from the soil but from water, from the bed of the sea. That makes them particularly interesting.

You must agree that the word "archaeology" has always been linked up with the digging of relics out of the ground. But the soil was not alone in gradually concealing material evidence of towns and villages, houses and burials, irrigation canals and roads, battle-fields with their blood-stained weapons, corpses, helmets and broken war chariots, wells in deserts, strongholds and temples, and thousands upon thousands of other traces of man on our small and not very young planet.

Dust and ash from fires were not all that buried this evidence. Water is also a grave of traces of human life on earth. The ocean has been combating land ever since it came into existence, and has triumphed time and again. It has inundated numerous human settlements, and continues to inundate them to this day. If the Dutch had not fought the ocean there would have been nothing left of

their homeland. If the search for Spina had not been undertaken by Nereo Alfieri but by somebody else a thousand years later, that somebody would have had to look for Etruscan relics on the bed of the sea, which by then would have covered the present swamps in the mouth of the Po.

Although archaeological work is much more difficult in water than on land it is also much more fruitful.

Let us briefly examine the pros and cons of submarine archaeology.

The pros are extremely vital. First and foremost, an object buried by water slips out of reach of human hands. We must remember that through the ages the worst destroyers of relics were people. On the sea bed cultural relics were not destroyed by invaders, stolen by treasure-hunters or dug out of the ground by a plough. No wild boar accidentally brought them to the surface. In the sea fish do not dig into the silt so ferociously, and it is not trampled by elephants or hippopotamuses. No matter how frail an object is, it reaches safety once it gets to the bottom of the sea, which is the most reliable custodian of artifacts that can withstand the action of the water.

These are the most important pros.

What about the cons?

Unfortunately, there are as many of them as pros.

The chief of them is that man is not a fish and does not feel as free in water as on land. He needs air and cannot reach any depth. Moreover, under water he has to work in semi-darkness. Another fact is that silt buries objects so that even sunken ships are hard to recognise.

In recent years, however, people have learned to more or less cope with the sea and have developed means that enable them to feel much more comfortable in water. The invention of the aqualung has solved many difficulties.

Despite all its merits the aqualung has not resolved the problem of swimming at any depth. The problem of

pressure that can flatten man into a flounder remains to be solved. But we are grateful to the aqualung for what it has given us. No wonder the most diverse sciences have eagerly seized upon it.

Oceanologists were the first to appreciate its advantages. They were followed by geologists, who set out for the floor of the sea in search of oil-bearing strata. The young Soviet geologist O. Leontyev, for example, used an aqualung to survey the floor of the Caspian over a distance of about 200 kilometres.

Biologists, too, saw possibilities in the aqualung. With its help they could survey the ocean as a source of food and other riches. Of all the wealth of the sea we only use fish and that only in infinitesimal quantities. The quantity of, say, sponge, weeds, pearls, amber and coral that we get from the sea is even smaller.

Biologists are studying plankton, on which the myriads of fish feed, in order to find out if it can be turned into a food product for man. They are also studying weeds, marine shrubs and all other species of marine plants. They want to know if these plants can be used in marine farming, which will undoubtedly be promoted in the near future. If weeds, many of which are extremely nourishing, can be used as fodder, it would stimulate livestock-breeding on desert shores.

Another problem is whether in addition to fishing man can breed fish in the sea. After all, man is breeding livestock in the boundless expanses of the steppes. Why then does he not breed fish in the boundless expanses of the sea?

In the sea biologists have established many new facts. One of them is that fish are not mute. Each species makes a sound of its own: herring whistle, saurel make a barking sound, grey mullet make a clicking sound, burbot grunt. In addition to making sounds, fish react to them. In *Adventures in the Sixth Continent*, the name he gives

to the World Ocean, the Italian Folco Quilici makes fascinating comments on the problem of why a shark instantly attacks a fish in agony but does not react to a newly-killed fish if it had not died in water. He describes how the biologist Professor Baschieri, who was swimming with an aqualung in the Red Sea saw a sextette of large tunny heading rapidly for him. Each of the fish weighed at least 50 kilos. Instinctively, as though warding off a blow, Baschieri raised his gun. This abrupt movement frightened the tunny, which promptly turned away in the manner of a fish that has received a wound.

A second later (the tunny were already out of sight) three sharks appeared and circled around Baschieri with the indignation of waitresses who have been called by mistake. What brought the sharks?

They came with the speed of lightning because they heard a familiar sound—a cry of alarm or fear by the six tunny, which saw the barrel of a gun trained at them. The same sound is made by a wounded fish. In this case it would be absurd to suppose that the sharks were drawn by the smell of blood or of prey desperately fighting for its life at the end of a harpoon. There was no trace of either the one or the other. Unquestionably, they were drawn by a sound that cannot be heard by human ears.

The sea has attracted geographers, physicists and geophysicists, to say nothing of film producers, photographers and artists. Yes, artists have gone down into the depths of the sea together with scientists, lured by the incomparable range of colours that unfolded before them. They were not deterred by the fact that ordinary paints are washed away by the water and that canvas cannot be adapted to submarine painting. They compelled chemists to develop water-proof paints and fabric to supplant canvases.

Naturally, ichthyologists and fishermen wanted information about the submarine world earlier than anybody else.

For thousands of years man has been casting his net into the water, but has he ever seen how fish enter his nets? Or how they dodge a trawl? Whether they jump or turn away? The answer to these questions held the key to unerring fishing. Or take another riddle. Why does a shoal of herring, so closely packed in the day-time that a stick stuck in it does not sink, scatter at night?

Jacques Yves Cousteau gives a magnificent account of trawling.

"We decided to film a trawl moving along the bottom of the sea. Nobody had seen a trawl directly in action....

"After I had selected a vantage point over the weed-overgrown bed I saw the trawl approach. Dragging at the end of the line, its gaping mouth crushed the reeds and sowed confusion among the delicate inhabitants of the submarine prairies. Fish darted in all directions like rabbits before a mower. The enormous sack of the trawl, bloated with water, sailed past me. The crushed reeds slowly straightened themselves. I was amazed to see how many fish saved themselves from those fearful jaws. Didi (Ferdinand Dumas, Cousteau's colleague) hung on the line head first and filmed these dragon jaws to show how many fish escape and how much harm is done to the submarine grazing ground."

When man cast his net blindly did he ever stop to think of the damage he did to the submarine pastureland? Today, with the picture of this destruction before us, there is plenty of food for thought.

Archaeologists, too, were among the first people who enthusiastically penetrated into the depths of the sea.

At this point we must make ourselves clear. Whom should we call a submarine archaeologist? Anybody who finds an ancient statue or the remains of Neolithic pile dwellings on the bottom of the sea or only a historian who perhaps finds nothing in the water but nonetheless conducts a purposeful search? I would say the name applies

only to a person who conducts underwater searches purposefully and knows beforehand (at least roughly) what to look for in a given region of the sea. This does not in any way belittle the importance of lucky finds, no matter who makes them.

Having made this point clear, I feel obliged to speak of the work of Ruben Orbeli, to whom underwater archaeology owes more than to any other scientist.

In the twenties and early thirties the romance of adventure surrounded the letters SUE, which stood for Special-Purpose Underwater Expedition. These letters made people think of the salt air of the sea, storms and squalls, of the masts of sunken ships with fish swimming over them, and of heroic divers in their spacemen's suits salvaging ships in seas and rivers so that they could be used again. The expedition salvaged the ice-breaker *Sadko* from the bottom of Kandalaksha Bay in the White Sea, and the *L-55*, flagship of the British submarine fleet that during the Civil War tried to steal into Kronstadt but was sunk in the Gulf of Finland, where cockle-shells collected on its sides.

In short, this was a salvaging expedition organised to save the country's money, clear the fairways of the mines left as "momentos" by the interventionists during the Civil War and raise ships from the bed of the Baltic, Black, Caspian and polar seas and the Volga and the Dnieper.

In 1934 SUE asked Professor of History Ruben Orbeli to write the world's first scientific history of submarine work from ancient times to our day. The task delighted the scientist. In a new light he pored over every book that could tell him anything at all about divers.

His attention was attracted by the works of Leonardo da Vinci. He could not believe that this versatile genius, who spent his whole life trying to penetrate the mysteries of flight and left behind him so many fruitful ideas for

air navigators, did not give any thought to how people behave in water, by analogy at least. Orbeli read through the colossal legacy of manuscripts left by da Vinci in an effort to find what he had to say about man's conquest of the deep.

It is fascinating to read through the manuscripts of geniuses, to follow the train of their thoughts and to see what obstacle stopped them. The obstacle, whatever it may be, rises before you in its full stature and you visualise it much more clearly than ever before: you had never stopped to ponder over it because some genius had surmounted it for you. You see the huge number of words that were half-written and rejected until the needed word was found, a word that fitted the thought exactly. You begin to understand that genius is not something drawn from inspiration but the result of tremendous, truly titanic and intrinsically human labour. The grandeur of a genius' ideas communicates itself to you. No matter how many times you read the works of a giant intellect, be it Marx or Lenin, the novels of Tolstoi, the pamphlets of Swift or the sonnets of Shakespeare, you always find something new, something you have missed that instantly stimulates your thoughts, makes you ponder over what surrounds you at present and helps you to get a deeper knowledge of the world in which you live.

The works of Leonardo da Vinci, both his paintings and scientific notes, belong to that class. He was so far ahead of his time that to this day one can keep drawing on the store of his ideas.

But reading da Vinci's notes is a pleasure only after you have already studied them and their purport becomes clear to you. Before that it is a torture.

He was left-handed and his childhood habit of writing not from left to right but from right to left persisted to the end of his days. All the letters in his notes are turned inside out and in order to be read they have to be held in

front of a mirror. He wrote quickly, his hand barely managing to keep pace with his thoughts. One finds the same swift writing in Pushkin and Lenin. In order to speed up his writing (he lived before the days of shorthand), he almost constantly abbreviated words, combining two or several words into one and leaving much unwritten altogether

The age da Vinci lived in witnessed a life and death struggle between the Catholic Church and the titans of the Renaissance. The church burnt at the stake or tortured to death a countless number of outstanding minds. Throughout his long life da Vinci was constantly under the threat of being accused of sorcery and condemned to the stake. The church was merciless to its enemies, to the people whose discoveries undermined the foundations of belief in God and glorified human might. Da Vinci was never a friend of the church.

That made him devise many ways of enciphering his ideas in his manuscripts, particularly when he expounded views that nobody else had set forth before him. These views are especially important to us today. In many cases he substituted the letter *g* for *d* and vice versa, or *i* for *u*. Or he separated words by dots, or, on the contrary used no punctuation marks at all. Or he wrote the letters upside down.

For students of da Vinci's manuscripts there is a special table of the abbreviations that he used. But this table does not cover even a small portion of the devices he used to confuse anybody reading his notes.

Moreover, he wrote on any piece of paper he could lay his hands on. Ideas on, say, mechanics, can be found in a notebook devoted to anatomy, while ideas on aviation are jotted down on a sketch of a youth's torso. Quite a few of his notes are written in the following vein:

"Why I do not describe my method of swimming under water, how long I can go without eating, and why I do not

publish or disseminate this? Because of the wicked nature of people, who would commit crimes on the bed of the sea by destroying ships from the bottom and sinking them together with the people on board."

Da Vinci's method of swimming under water and of going without food was buried with him. But the mere fact that he mentions such a method meant that he had invented it and in all probability tested it on himself before making his categoric statement.

Ruben Orbeli brought to light many of da Vinci's ideas. He believes it very likely that da Vinci solved the problem of diving without a hose or pipe. In other words, early in the sixteenth century he worked on a problem that was solved with the invention of the aqualung in the mid-twentieth century, after oxygen cylinders became available in every chemist's and people learned to increase the pressure of air up to 30,000 atmospheres with the aid of multi-stepped compressors. Compressed air has been used in practice ever since man invented the first bellows and the first blow-pipes, but the theory was developed only in the past century. In this problem, as well, the genius of da Vinci, as Ruben Orbeli established, outpaced science by more than three centuries. Among da Vinci's inventions, Orbeli found an instrument for determining the density of air. This clearly showed that he saw that air is not indifferent to compression. Did his mind turn to oxygen? Writing of breathing under water he said it was necessary to provide man with *alito*, implying something resembling air. Does this not indicate that he meant oxygen?

Orbeli's findings created a furore among scientists studying Leonardo da Vinci's manuscripts. The Italian Scientific Society, set up for the express purpose of studying da Vinci's legacy, announced that Professor Orbeli must have found some new manuscripts in the U.S.S.R, because it was quite inconceivable that he could reconstruct da Vinci's obviously long study of means of conquer-

ing the submarine world solely from old manuscripts, whose facsimiles had been repeatedly published.

But this splendid achievement was only part of the tremendous job that Orbeli shouldered when he undertook to write a history of diving. The farther he progressed in his work the more clearly he saw how diving was linked up with the most diverse spheres of human life and activity.

Thousands of years ago piers and wharves were built in Egypt, Phoenicia and Greece with the help of divers. The methods of catching fish by throwing fences and nets across rivers were likewise evolved thousands of years ago. During the Greco-Persian wars 2,500 years ago (this date is recorded by contemporaries) divers sank enemy ships, cutting anchors free in storms or drilling holes into ships below the water-line. Many centuries ago people dived into water for copper. In ancient Greek literature there is mention of "copper-divers". Moreover, when did man first dive for pearls, corals and sea-shells? Then what about the divers who hunted for treasure in sunken ships? The science of salvaging ships, a relatively young branch of human activity, has accumulated a vast store of experience.

With the same thoroughness and industry with which he studied da Vinci's manuscripts Orbeli collected every scrap of evidence on diving, utilising for this purpose his knowledge of Greek, Latin, Russian, French, Italian, Early Italian, Spanish, English, German, Swedish, Armenian and Georgian languages.

As he writes in his article *In Favour of Submarine Archaeology*, he came round to the opinion that the time had come to follow up the history of diving by elucidating the problem of what "has been given to history by divers" and mapping out ways in which divers can be used to reconstruct history. Alexander the Great strictly enjoined divers to inform his wise tutor Aristotle, who was "versed in all sciences", of "everything they see under the water

so that nothing escapes his notice". Having vastly superior means of studying the submarine world than Aristotle and Alexander the Great, can we afford to ignore this enviable possibility of augmenting our knowledge?

Orbeli's ideas in this field received a further impetus by the discovery of the famous Bug dugout. Hearing that five "Zaporozhye or Turkish" boats were sunk "in ancient times" in the Bug near the town of Pervomaisk and that somebody had unskilfully tried to raise a very old dugout from the bed of the Bug near the village of Sabotinovka and torn off a part of the bow, Orbeli immediately set out for the village. As soon as he arrived he located 15-year-old Volodya Glukhoi, who found the dugout. The lad said he knew where it was and offered to take the scientist there. It was true, he said, that somebody had damaged the dugout, tearing away not a part of the bow but of the stern. It was about two kilometres from the village, at the foot of Melnitskaya cliff.

The cliff was so steep that even the 15-year-old boy climbed down cautiously. Orbeli kept pace, even hurrying him. Sure enough, there was a dugout in the water.

One look was enough to tell that it was made long before the Zaporozhye Cossacks appeared. Orbeli realised that it was an extremely important find.

On the next day, September 12, 1937, it was raised out of the water. Splendidly preserved, it was huge and almost symmetrical, hollowed out of an oak trunk: "all along its starboard side there were traces left by slanting blows inflicted by a blunt weapon. One gets the impression that in addition to striking rocks or the shore it had been attacked".

But who did it belong to? The Scythians? Or the Slavs? An analysis of the wood showed that it was at least 2,500 years old.

The dugout was triumphantly taken from Sabotinovka to Leningrad: the Sabotinovka Collective Farm gladly

gave Orbeli a heavy bullock cart on which the dugout was taken in a train and placed in the custody of the Central Naval Museum.

Encouraged by this find, Orbeli extended the field of his hydroarchaeological investigations. Who knows what heights hydroarchaeology might have reached if the war had not broken out and Orbeli had not died on May 9, 1943, exactly two years before V-day.

However, Orbeli succeeded in doing much to promote submarine archaeology and popularising it within the short span of time from the finding of the Bug dugout to the outbreak of the war. In Koktebel Bay near Feodosia he discovered the remains of a large Scythian-Tauric port, which flourished until the arrival of the Hellenes, after which it was swallowed up by the sea. He explored Taman Bay in order to find the exact site of Tmutarakan, which was the southernmost stronghold of Rus and one of the most celebrated of the ancient Russian towns. He convincingly showed the need for going over from scattered, episodic hydroarchaeological searches to the compilation of a single hydroarchaeological map of the country and "transferring it to the mute map of the seas".

Among his dreams was one which he even hesitated to write about, confiding it only to close friends. This dream, the unravelling of the riddle of Atlantis, is mentioned by Marietta Shaginyan in her article *The Man and the Scientist.*

A devotee of science such as Orbeli could not help but be fascinated by this riddle. Was Plato's story of the lost continent and his account of how the story reached him simply a piece of poetical fantasy? Crito, in whose name Plato tells the narrative, says that when he was a boy he heard of the flourishing country Atlantis from his nonagenarian grandfather, who had, in his turn, heard about it from his friend Solon, the famous Athenian lawgiver. Solon

got the story from an Egyptian priest, who had access to ancient temple chronicles, having met him during his wanderings in Egypt.

The story had made a rather long journey, but in spite of that it has an authentic ring about it. There is nothing to indicate that it was the product of somebody's fancy. It contains details that Plato's sources could not have invented.

For example, Critо said Atlantis was situated west of the Pillars of Hercules and maintained that if a westward course were steered from it—remember this point—a new continent could be reached.

Ever since Columbus discovered America we have known there is a continent in the west. But how could Plato's ancestors know of this when they had no knowledge of either the route or that America lay at the end of it?

Let us, for a moment, suppose that this was an invention, after all, and that in this given case the coincidence is accidental and only got us entangled.

But what about the many, I repeat, many similar coincidences in Plato's story?

Over the past few years archaeological excavations have brought to light that the Hellenic culture was preceded by an Aegean culture and mighty states. The ancient Greeks knew nothing of this. Yet Plato begins his story about Atlantis with a description of powerful states that preceded the Hellenes. He even gives the lay-out of the capital of Atlantis which duplicates the lay-out of Tenochtitlan, the Aztec capital (and now the site of Mexico City).

The entire story, as told by Plato, is woven of similar coincidences.

There are other astonishing coincidences; the chronology of the ancient Egyptians and Assyrians is the same as that of the ancient Mayas in America.

Can we assume that they knew about each other? We have no grounds for that. But even if we make this

assumption, it will not explain why they selected the same date from which to begin their count of time.

Our only other conjecture is that this concurrence of the calendar of three different peoples is due to some staggering event known to them, an event that to them could only have seemed to mark the end (or beginning) of the world. That is probably why it was retained in the memory of these peoples for thousands of years.

What was this event?

The Egyptians and the Assyrians give the exact date: 11542 B.C. This is approximately the date the chronology of the Mayas also begins. Present-day geologists have learned why this was a noteworthy date in the history of the earth. It was just at this time that a fearful cataclysm shook the Atlantic: volcanic upheavals (probably both surface and submarine) broke down the barrier in the way of the Gulf Stream in the Atlantic, giving it access to the Arctic Ocean and the north-western seaboard of Europe. A thick layer of volcanic dust was deposited on the floor of the Atlantic, and in Europe the climate grew considerably warmer due to the new direction taken by the Gulf Stream, which put an end to the last glacial epoch.

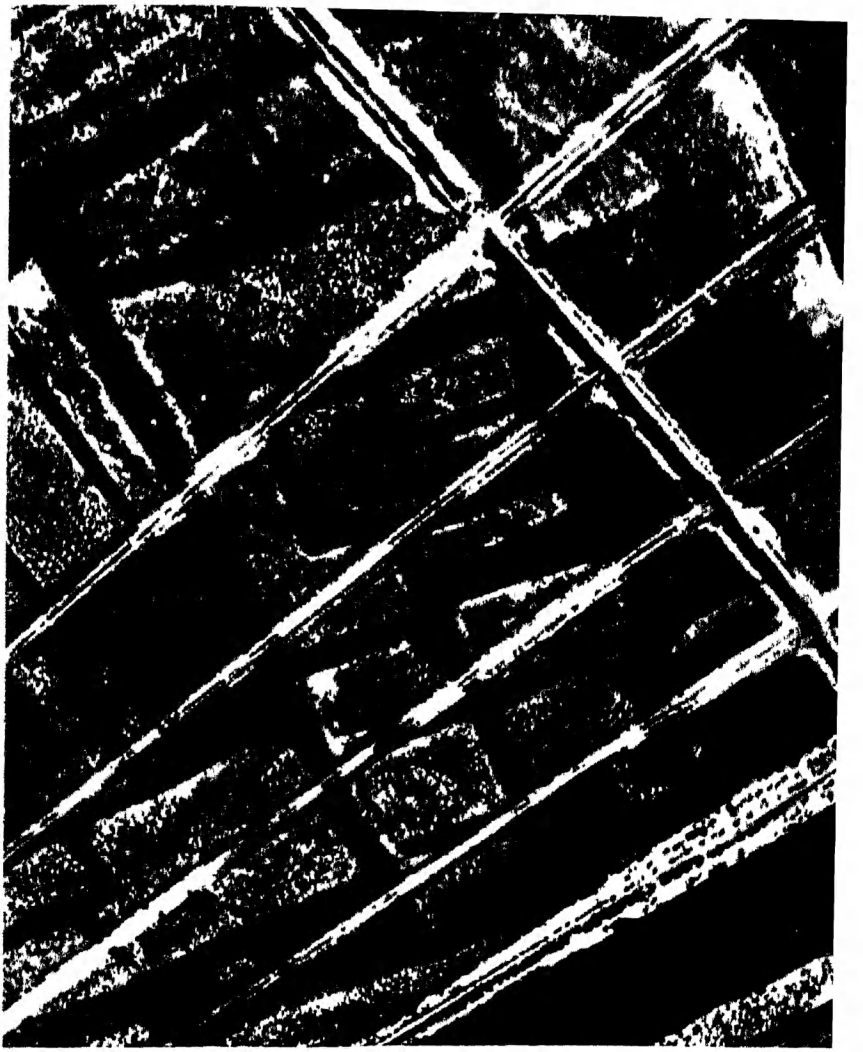
What prevented the Gulf Stream from reaching the Arctic Ocean in the days before the cataclysm?

Atlantis. That is the opinion of present-day scientists, including E. V. Khagemeister, the eminent Soviet authority on these geological problems.

Only a world-wide cataclysm like the disappearance of an entire continent or, at least, of a huge island as a result of simultaneous earthquakes, volcanic activity and floods, could have left such a long-standing imprint in the memories of people. It is therefore not surprising that echoes of these memories reached Plato.

Incidentally, this might have been the cataclysm that gave rise to the legend of the Flood. A tenacious legend, too, it has been preserved by very many peoples.

Ruins of Roman settlements near Spina. The lines forming the geometric pattern show the position of ancient walls. The long diagonal line running across the pattern is a present-day canal. On its left is the shadow of the aircraft from which this photograph was taken



Drainage canals (light lines in the photograph) run across the site of Spina. The dark lines indicate ancient canals. The light rectangles framing the ancient canals are the blocks of an Etruscan port

Fourth century B.C. duck-shaped vessel. The winged woman's figure decorating it is that of Laza, an Etruscan deity

Bowman with a feather headdress found at Jabbaren

However, despite the extraordinary significance of these coincidences, only archaeological finds can provide irrefutable proof that Atlantis ever existed. This was what Ruben Orbeli dreamed of.

But the war and the scientist's death after a terrible winter in besieged Leningrad ended his work in promoting submarine archaeology.

Soviet scientists returned to submarine archaeology only in 1951, when P. Kvachadze, a member of a collective fishery, reported to the Museum of Regional Studies in Poti that on a clear day he saw the outlines of some strange ruins on the floor of Lake Paleostom.

This report caused a stir at the museum. On the next quiet, sunny day a team headed by V. Gauga, the museum's director, with Kvachadze acting as its guide, went to the lake. Kvachadze showed where he saw the ruins and a diver was sent to the bottom. He brought back potsherds and the bones of animals.

The search was continued with the result that the Poti Museum now has a large collection of antiques, including Greek bronze artifacts, tools, magnificent ceramic articles, and several skilfully worked stones that were obviously part of a house.

The name of the settlement was deciphered. It proved to be Phasis, a well-known Greek colony in Colchis. The lake, on whose bed Phasis was discovered, was once part of Colchis Bay in the Black Sea (Paleostom means ancient estuary). Gradually filled by alluvium carried by the Rion River, the bay was separated from the sea and turned into a lake, thus hiding the ancient colony for thousands of years.

Hydroarchaeologists also established the exact site of the Battle of the Ice. This was very important to military historians.

The chronicle tells us that the battle took place "at Voronye Rock in a narrow neck of Lake Chud". But the

chronicler did not witness the battle, recording the story as told to him by other people. This, naturally, raised doubts as to the accuracy of the description, especially as no traces of the battle were found in the ground. The Teutonic Knights, it will be remembered, were drowned under the ice.

Georgy Karayev, the Leningrad military historian (who is a co-author of the thrilling historical novel *Pulkovo Meridian*), organised an archaeological expedition to the site of the Battle of the Ice. An important role was played by divers using aqualungs.

Karayev wanted to know why the ice suddenly gave way under the Teutonic Knights. It held firm during the battle and cracked after it. Why did it not crack under the feet of the Russian army?

The answer was found on the site. Voronye Rock no longer exists, and in the lake there is only Voronye Island. True, as in the case of lakes Pskov and Tyoply, the configuration of Lake Chud has undergone considerable changes since 1242. If Voronye Rock ever existed it must have been submerged.

The Teutonic Knights and the hosts of Alexander Nevsky moved to the battle-field along the frozen rivers. In the forests surrounding Lake Chud these were the only roads a large army could take (as a matter of fact they served as the trade route between Riga, Pskov, Novgorod and Derpt). These roads crossed near Voronye Island in the region of Lake Tyoply. This was its narrowest place and, possibly, the "neck" mentioned by the chronicler.

Another circumstance, the name of the lake, drew Karayev's attention. Why was it called Tyoply*? There had to be a reason for it.

Questions put to the local population and the search conducted by the divers provided the explanation: indeed,

* Meaning "warm" in Russian.—*Ed.*

in this lake the ice is never thick because of the powerful underground springs. We must assume that in preparing for the battle Alexander Nevsky studied the terrain and did not leave the valuable information about Lake Tyoply without attention. When the formation of the Teutonic Knights was broken and they were put to flight, he chased them to the place where he knew they would perish.

Near the underground springs and Voronye Island, the expedition's divers discovered a huge submerged rock and beside the remains of defensive walls. Hydrologists confirmed that in the thirteenth century this rock was exposed on the surface near the "neck" which disappeared with the passage of time when the lake expanded and flooded the defensive walls as well.

There was now no question about the rock found by the hydroarchaeologists not being Voronye Rock. The geologists who surveyed this area confirmed this conclusion Their instruments showed that a large quantity of metal still lies around the submerged rock on the floor of the lake.

Karayev hopes to recover the weapons, armour and bones of the Teutonic Knights.

In the lofty mountains of Kirghizia hydroarchaeologists are planning to investigate the city of Chuchugen, which lies on the bottom of Lake Issyk-Kul.

At one time the Issyk-Kul hollow was inhabited by the Sani and Usuni tribes, and Chuchugen was the capital city of the Usuni rulers. It sank to the bottom of the lake probably as a result of an earthquake, a frequent phenomenon in Kirghizia. As though grieving over its tragic fate, this submerged city continuously reminds people that it exists by throwing up mouldy coins or an ancient bronze or copper pot on to the lake shore. There are many legends about Chuchugen. They say that on a clear day the mysterious city can be seen deep in the lake.

In the Black Sea Professor Blavatsky is continuing his studies of antique history Of all the hydroarchaeological work in the Soviet Union today these investigations are the most important.

In the history of Hellas an important role was played by the relations between Athens and the peoples inhabiting the Black Sea basin, particularly the Scythians. These relations went much farther than the export to Greece of grain and slaves. In the end the Greeks founded colonies along the Black Sea, and the relics left by them shed light on the history of both the Soviet Union and ancient Hellas.

A Greek triple bas-relief marble tombstone dating from the fifth century B.C. was found in 1953 near the shore in Sukhumi Bay at a depth of only two metres. It was so exquisitely made that it is hardly worth accusing the English writer James Aldridge, who saw it in the Sukhumi Museum, of exaggerating when he rapturously wrote that it is "probably one of our century's most valuable finds dating from the Ancient Greek period of human history".

At present Professor Blavatsky is excavating Phanagoria, which was a major port of the Bosporan Kingdom. It now lies on the floor of Taman Bay at a depth of two or three metres. The depth of the bay itself averages about five metres. This has brought the professor round to the conclusion that the notion of where the shoreline passed in ancient times has to be revised and that possibly Taman Bay was non-existent.

This conclusion was reached after the bay had been carefully measured in the summer of 1958. That same summer Professor Blavatsky's expedition established the lay-out of the submerged part of the city. An area of nearly 15 hectares of the city lies under the sea.

Statues, the remains of ships and so on are of course much more spectacular than the lay-out of a lost city. However, the surest way of multiplying the successes of submarine archaeology is to work on the basis of a lay-

out. That is the road Soviet archaeology has chosen. In 1957, before moving to the Phanagoria site, Professor Blavatsky's expedition surveyed the submerged portions of the ancient towns of Nympheus and Hermonassa, obtaining a "preliminary outline of the sea-engulfed portions" of the latter town. As Professor Blavatsky says, "diving is allowing the field of operations of an expedition to be more than doubled", and the exact lay-out of ancient towns is therefore of vital importance.

Although mud is not a very critical hindrance to the reconstruction of the lay-out of towns, because the ruins of large structures such as piers, fortress walls and houses jut out even if the layer of mud is very thick, it is a frightful obstacle to the finding of small objects. This is one of the most harassing problems of submarine archaeology.

Indeed, how can one dig under water? It is enough to stir the silt simply by stepping on it for the water to become turbid and reduce visibility to zero. Suffice it to recall the story of the English frigate.

She set sail in 1799 from Yarmouth with a cargo of bullion worth £1,175,000 for Hamburg. A storm hit the vessel near Holland and she sank at the entrance to the Zuider Zee.

Although the crew and the passengers perished in the storm, rumours of the bullion instantly spread through Holland and hordes of treasure-hunters began diving for the gold. In the course of 18 months about £80,000 worth of bullion was recovered. Then the ship was buried by sand, but the Napoleonic wars prevented any serious attempt from being made to organise a serious search.

The frigate was remembered only 15 years later, in 1814, when the Dutch government set up a special expedition with the object of recovering the treasure. The expedition worked for 40 years and salvaged £40,000 worth of bullion.

After that the frigate disappeared again.

The next time she was found was in 1911 by the English skipper Gardner, who was an authority on the local underwater currents. The vessel lay buried beneath a nine-metres layer of sand.

The work proceeded throughout the summer of 1911 and toward the end of the season divers finally found where most of the bullion lay in the vessel. Autumn storms prevented the ship from being raised and the work had to be postponed until the next year. However, when the divers resumed their work there was no trace of the vessel, and even Gardner was unable to determine its location. The perfidious silt is guarding its secret to this day.

Professor Blavatsky has suggested recovering antiquities from the bed of the sea with the aid of small caissons in shallow water and powerful dredges in deep water. Where a thick layer of silt covers ships, buildings and other large objects, the professor suggests geophysical methods of investigation.

Important discoveries unquestionably lie ahead. There is no doubt that in the near future the submarine kingdom will be forced to yield up the secrets of the life of its inhabitants and also answer many riddles of the history of man.

We are living in an age in which knowledge is being accumulated by leaps and bounds. We have already stepped across the threshold of outer space and four-kilometre depths in the ocean, and geophysics is enabling us to see the structure of our earth.

How slowly time dragged before and what a furious pace it has set today! We cannot, as before, postpone the study of new developments in science and technology "to a later date".

With the Earth satellite eclipsed by the rocket that has become a satellite of the Sun, with polymers already in

use in households and with man making materials that are unknown in Nature, we can no longer postpone pondering over atomic fission, the theory of relativity and the laws of outer space. Man has grown out of his boyhood. With the world becoming too small for him, he has set his mind on conquering outer space and the ocean depths.

TO THE READER

Progress Publishers would be glad to have your opinion of the translation and the design of this book.

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